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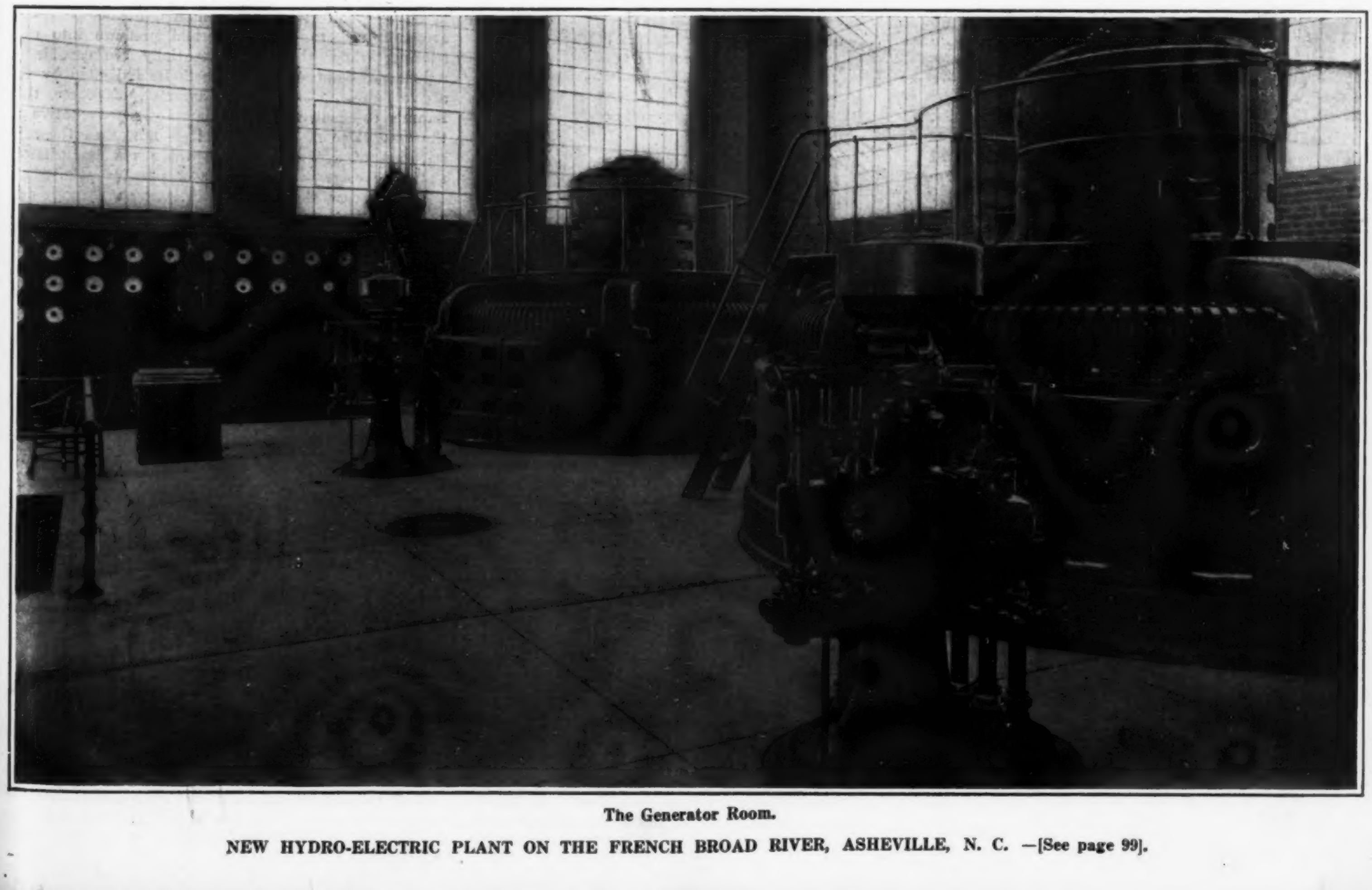


The Generator Room.

NEW HYDRO-ELECTRIC PLANT ON THE FRENCH BROAD RIVER, ASHEVILLE, N. C. —[See page 99].

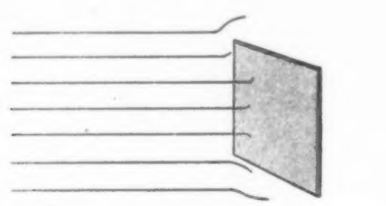
Aeroplane Efficiency*

A Skeleton Framework of Theory as a Guide for Practical Construction

By Algernon E. Berriman, M.Inst.A.E., Technical Editor of *Flight*

Efficiency in an aeroplane, as in any other machine, is the determining factor in its capacity to do big work on a limited supply of fuel. Long journeys and flights of extended duration are limited by this, quite apart from any consideration as to the stability of the machine, the skill of the pilot, or the behavior of the weather.

From land to land across the Atlantic Ocean, the shortest distance is some 1,700 miles, which would occupy about twenty-eight hours on a machine averaging 60 miles an hour. Fuel is being consumed during



NORMAL PRESSURE
$= \cdot 003\,V^2$
Fig. 1.

the whole of this time at a minimum rate of 0.65 pint of gasolene per horse-power hour, whence at least ($28 \times 0.65 = 18.2$) pints would be needed for every horse-power developed by the engine employed. This quantity would weigh, for gasolene of 0.7 specific gravity, approximately 15 pounds.

In flight an engine works at full power all the time, so there is no discount on the above figure when it is multiplied by the power of the engine in order to obtain the total quantity of fuel consumed.

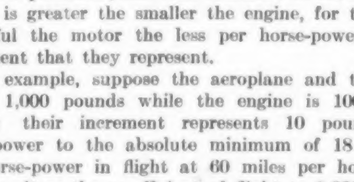
The engine itself would weigh at least 3 pounds per horse-power, whence the power-plant alone represents ($15+3=18$ pounds) per horse-power as a minimum for the journey. The engine that would carry itself across the Atlantic must, therefore, be capable of supporting 18 pounds, in flight at 60 miles per hour, per horse-power developed.

One horse-power is equivalent to 6.3 pounds thrust at 60 miles per hour, and the ratio 6.3 to 18 = 0.35 represents the minimum thrust-lift ratio, "efficiency," or, as I prefer to call it, "co-efficient of flight," for this imaginary system in which the power-plant is supposed to be flying without wings or propeller.

Directly the aeroplane and pilot are introduced into the calculation, this minimum value is altered considerably, for however light you may conceive it possible to build a machine, the man, at any rate, will weigh 150 pounds if he is a normal specimen of humanity. This weight and the weight of the machine are fixed quantities, and their influence on the efficiency factor is greater the smaller the engine, for the more powerful the motor the less per horse-power is the increment that they represent.

For example, suppose the aeroplane and the pilot weigh 1,000 pounds while the engine is 100 horse-power; their increment represents 10 pounds per horse-power to the absolute minimum of 18 pounds per horse-power in flight at 60 miles per hour, and thereby alters the co-efficient of flight to 0.225.

Alternatively, if only 50 horse-power is employed, the efficiency ratio is raised to 38 pounds per horse-power, which is equivalent to a co-efficient of flight of 0.166. Thus, the less powerful the engine the more efficient must be the aeroplane as a whole, consequently *the chances* of building a machine that will do the job,



SKIN FRICTION
$= \cdot 000018\,V^2$
Fig. 2.

increase with the power of the engine, provided always that such an engine is itself as economical and light per horse-power as one of lower power.

The extra total weight of fuel required for the larger engine only affects the question in so far as it may adversely influence the design of the aeroplane proper, on which, of course, it must be carried. So far as it represents dead weight, it is proportional to the power developed, and, therefore, it is immaterial whether there is much of it or little.

If there is a difference in fuel economy between one engine and another, the length of the journey determines whether this difference is important or not, for the effective difference in weight per horse-power brought about thereby is ascertained by multiplying the difference in the rate of fuel consumption by *time*.

If, on the other hand, the difference between two engines is solely one of weight per horse-power, then the effective importance is uninfluenced by the nature of the flight. Also it is generally small by comparison with the increment represented by the weight of the aeroplane and pilot, as explained above. For example, if the engine weighed 4 pounds per horse-power, instead of 3 pounds per horse-power, this would only mean a difference of 1 pound per horse-power, whereas the aeroplane and pilot represent an increment of at least 5 pounds per horse-power with a 100 horse-power engine.

For the sake of argument, let us assume that the engine develops 100 horse-power and works under the above conditions. It will require ($100 \times 15 = 1{,}500$) pounds of fuel for the journey. This quantity of gasolene would occupy (at 43.4 pounds per cubic foot) nearly 35 cubic feet, and could be carried in a cylindrical tank 2.5 feet in diameter by 7 feet long. This investigation is important; it shows whether it is practicable to carry the initial quantity of fuel that must be put on board before the start of a long flight. Also it is some indication as to the strength and size of the aeroplane that would be required to carry the fuel in addition to the pilot and any other extra load.

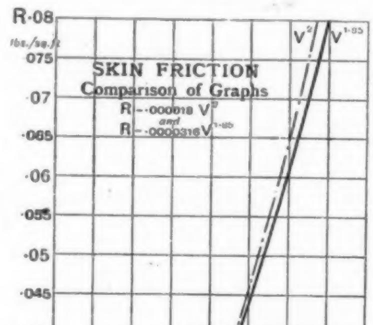


Fig. 3.

It should interest those who have not previously studied this aspect of flight to observe that some fairly tangible conception of the problem is afforded by such a simple application of first principles in mechanics. None of the above deductions have been founded on any special knowledge of the laws of flight; it is simply and purely an armchair analysis of the fundamental situation, for all that has been done is to say what the co-efficient of flight must be if a certain weight is to be sustained at a certain speed by a certain power.

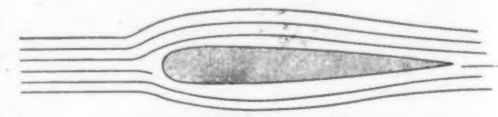
As the conception of a self-supported mass in continuous horizontal motion is not elsewhere presented by any ordinary problem in mechanical science, it often happens that even the trained mind fails to appreciate this fundamental simplicity of the case. When a definite weight is known to be supported in horizontal motion at a definite speed by the exertion of an engine of definite power, then these very data themselves establish the ratio of thrust to lift, that is, the measure of an aeroplane's "efficiency," which I have otherwise expressed by the more appropriate term "co-efficient of flight."

To know that a certain co-efficient of flight is obtainable is one thing, to know how to obtain it is another. Investigation of this side of the question leads on to a study of resistance to motion through the air and the lift of a wing in flight.

First, as to resistance generally. This is primarily of two kinds; in one part it is due to normal pressure caused by the wind striking against the face of a flat surface (Fig. 1), in the other it is due to "skin friction" caused by the wind rubbing against the sides of a plate that is moving edge on (Fig. 2).

Dr. Stanton, of the National Physical Laboratory, also various other authorities, have experimentally established an accepted formula for such normal pressure resistance in the expression $R=0.003V^2$, where R is in pounds per square foot of area facing the wind and V is in miles per hour.

In America, Dr. A. F. Zahm has experimentally



STREAM LINE FORM

Fig. 4.—Bodies of This Form Convert Normal Into Skin-friction.

provided a formula that has not been generally accepted, although one of the few that exist, in the expression

$$R=0.0000316V^{1.85}l^{0.93}$$

(where R = resistance of double surface per foot of span, l = chord of surface). This formula may be approximated for aeroplane wings, within the ordinary limits of modern flight speeds, by the simplified expression $R=0.000018V^2$ (Fig. 3). And, as the expression itself is in doubt, there is little object in being particular as to accuracy in detail at the moment. In this expression, R represents the resistance per unit of *double* surface moving as a plate edge on to the wind. When the surfaces are separated, as in the formation of a box or casing, where they would be measured separately, the co-efficient in the above formula is halved to make it applicable to the single surface or external area.

The important point to observe is that the relationship between skin friction and normal pressure is represented by the ratio of 1 to, approximately, 300. In other words, you may use 300 square feet of edge on surface to inclose 1 square foot of normal area, if you can insure that this covering body is truly edge on in effect.

Bodies of streamline form (Fig. 4) as understood in naval architecture and in fluid dynamics generally, are supposed to convert normal pressure into skin friction; they, therefore, potentially are capable of reducing resistance within the limits indicated by the above figures. This always assumes, of course, that Zahm's co-efficient is approximately representative of the true state of affairs. If it is not, then the substitution of a more accurate value will immediately show the corresponding limits of possible gain.

In any case these figures at least suggest the importance of eliminating normal pressure from aeroplane design, by the use of bodies of streamline form to inclose the larger masses on the machine.

This body resistance—in which is included the resistance of the struts, wires, and all framework except that actually forming the wings—is a resistance that is proportionate to the square of velocity (according to

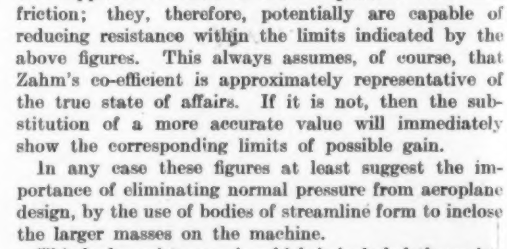


Fig. 5.—The Mass of Air Disturbed by the Wings Is Proportional to the Product of the Chord Into the Span.

the above expression) and is a kind of extra dead load on the machine. It bears no relationship to the lift of the wings, and is, consequently, a detriment to efficiency. It is very important to discriminate thus between body resistance and the resistance of the wings.

The resistance of an aeroplane wing in flight is itself of two kinds, one being the above-discussed skin fric-

* Reproduced from the *Journal* of the Society of Arts.

tion of the surfaces, while the other is a dynamic resistance due to the creation of the aerial wave that supports the machine in flight.

This latter we may call the resistance due to load, and it will be shown that it is a function of the effective angle of the plane. If the effective angle is reduced, the resistance due to load *per unit of supporting area* will be decreased, but in order to support the same total load the area itself must be increased, which in turn increases the resistance due to skin friction.

Hence, there is a relationship between the two kinds of resistance experienced by a wing in flight, which is why the wing needs to be considered separately,

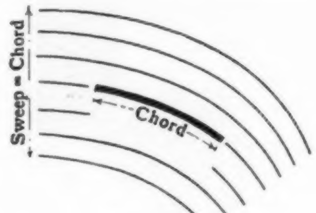


Fig. 6.—The Depth of the Stratum of Air Disturbed is a Function of the Chord.

and why it is not proper to include the wing surface with the body surface when calculating the skin friction resistance of the machine as a whole.

If Zahm's expression for skin friction is accepted, we may pass on to consider the resistance due to load. It is more convenient, as an intermediate step, first to find an expression for the lifting power itself.

On the hypothesis that an aeroplane is supported in flight by the inertia of the air, it becomes possible to apply the fundamental equation $P = mf$ (where P = lifting force and m is the mass under acceleration f).

In order to apply this fundamental formula, it is necessary to find plausible expressions for the mass of air simultaneously disturbed by the wing in flight, and also an expression for the acceleration induced in that mass.

As to the mass itself, it is obviously limited in two dimensions by the span and chord of the wing (Fig. 5). Its third dimension, which corresponds to the depth of the stratum disturbed, is supposed to be a function of the chord (Fig. 6) and to have a co-efficient in the order of unity. Whence we may write mass in the form ($\rho\ Ll = \rho Al$) (where ρ = density, A = wing area, L = span, and l = chord).

Next comes the question of acceleration, which, from the very nature of the function of a wing, is determined by flight velocity and angle.

What is the effective angle of a wing?

Some say θ, the angle of incidence, some believe in the angle of trail α, but I submit that the angle of deflection β is the most plausible measurement (Fig. 7). It is immaterial, however, what angle is taken if the assumption be that the air stratum itself is deflected to the assumed degree.

Assuming that the angle of deflection as defined in Fig. 7 correctly represents the actual deflection of the air stratum, and that the camber of the wing is such as to produce uniform downward acceleration in each air molecule, then the final downward velocity with which a molecule leaves the trailing edge is represented by the expression ($V \tan \beta$) and the rate of acceleration itself by the expression

$$\left\{ (V \tan \beta) \div \frac{l}{V} \right\} = (V^2 \tan \beta / l) \text{ (where } V = \text{feet per second).}$$

Thus, we have established plausible expressions for mass and acceleration, and their product should give a value for the lift or upward force of the wing in flight.

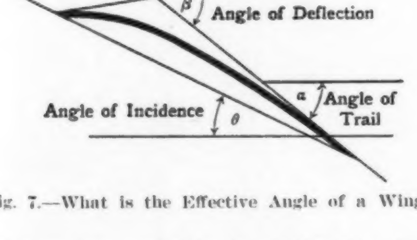


Fig. 7.—What is the Effective Angle of a Wing?

Combining these expressions in multiplication, it will first be observed that the chord factor (l) cancels out of the expression, and since the area factor (A) may be removed by working in units of a square foot, or other convenient measure, we are left with an expression in the order of ($\rho\ V^2 \tan \beta$). This, put into practical units for $\left(\frac{\rho}{g} = \frac{1}{400}\right)$ and (V = miles per hour) evolves the following definite formula for the lift of an aeroplane wing in flight $\frac{P}{\beta} = \frac{V^2 \tan \beta}{200}$.

The graph of this expression is given in Fig. 8.

The next step is to find an expression for the resistance due to load, which involves the assumption that this resistance is confined to the apparent energy in the deflected air stratum. Energy is represented by the fundamental expression ($\frac{1}{2}mv^2$) and we have already evolved expressions for mass (m) and downward velocity (v).

Of these: $m = \frac{\rho}{g} Al = \frac{Al}{400}$,

and $v = V \tan \beta$,

whence $\frac{1}{2}mv^2 = \frac{V^2 \tan^2 \beta l}{800}$ foot pounds per square foot of wing area.

Now this energy per square foot is dissipated $\left(\frac{V}{l}\right)$ times per second; hence, the power expended on load may be expressed

$\frac{V^3 \tan^2 \beta l}{800 l}$ foot pounds per second per square foot,

which may be converted to resistance by dividing by (V); whence, resistance due to load is $\left(\frac{V^2 \tan^2 \beta}{400}\right)$ pounds per square foot. (V is in miles per hour.)

The other part of the resistance to the flight of the wing is skin friction

$$R = \cdot 000018 V^2,$$

whence the total resistance $= \frac{V^2(\cdot 000018 + \tan^2 \beta)}{400}$.

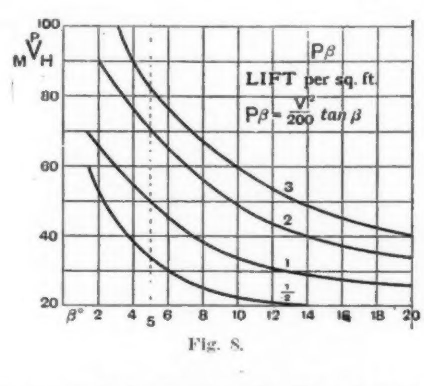


Fig. 8.

Having evolved expressions for lift and resistance, their ratio gives the co-efficient of flight for the wings alone. Thus

$$V^2\left(\frac{\tan^2 \beta}{400} + \cdot 000018\right)\left(\frac{200}{V^2 \tan \beta}\right) = \left(\frac{\tan^2 \beta + \cdot 0072}{2 \tan \beta}\right)$$

The graph of this expression is given in Fig. 9.

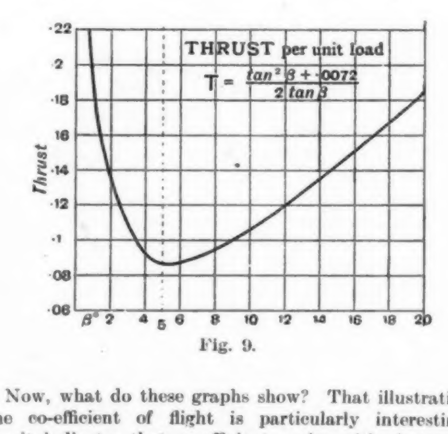


Fig. 9.

Now, what do these graphs show? That illustrating the co-efficient of flight is particularly interesting, for it indicates that co-efficient varies with the angle of the plane, is independent of velocity, and has a minimum value in the order of 0.085 for an angle of deflection of 5 degrees.

These numerical values result from the assumed co-efficient for skin friction and the density of the air; the principle of an angle of least resistance to flight is unaffected by their variation. That the co-efficient is independent of velocity is due to the absolute resistance and the absolute lift of a wing both being proportional to V^2. If the speed is doubled, the lift is quadrupled, and so is the resistance; their ratio is unchanged. It follows, therefore, that the most efficient variable speed machine is one having a variable area and not a variable angle. Also, that for a fixed area and weight there is a natural flight speed.

Since speed does not affect the co-efficient, it follows that, from the point of view of the *wings alone*, the speed should be suited to the use of an angle of least resistance. In the graph, a very flat chamber is indicated, which implies a very high flight velocity to attain the loading that is common practice to-day. It is in respect to the very heavy loading (weight supported per unit area) of their wings that aeroplanes differ from birds, which have proportionately far larger wings.

In the construction of monoplane wings, larger areas imply greater spans and involve the use of more constructional material per unit of area in order to maintain the same strength. Thus, the net lift of the wing per unit of area diminishes in larger sizes, thereby involving proportionately higher speed for the same loading; whence there are good grounds for the general impression that a monoplane is naturally a fast type of machine. Equally, it explains the *raison d'etre* of the biplane, which is the type for efficiency at slow flight speeds.

From the point of view of body resistance, a very high flight velocity is wasteful of power, but the magnitude of the loss depends on the efficacy of streamline bodies to reduce resistance. In practice, cambers representing far higher angles than that indicated as possessing least resistance are used, in order that machines of small area may rise at moderate speeds.

So, the significance of efficiency as a governing factor in long distance flights has been discussed, and a method of mathematical analysis has been suggested. This latter, I wish to say, is intended primarily as an elementary line of thought for students, analogous to presenting the problem of the steam-engine in the time-worn formula (*PLAN*/33000). It does not pretend to be either scientifically complete, nor is it based on practice. It is just a skeleton framework of theory intended to help those who have the concrete bricks of fact to make most use of them in building the houses of experience wherein a practical science can only abide.

New Hydro-electric Plant at Asheville, N. C.

By N. Buckner.

Our illustrations show some views of a hydro-electric power plant located on the French Broad River twenty-five miles northwest of Asheville. This plant has been in the course of construction for the past two years and has just been completed and put into service. Its normal capacity is 5,000 horse-power. The entire plant represents in round figures an expenditure of $500,000 and in its construction it was necessary to raise and rebuild two and a half miles of the track of the Southern Railway which skirts the river at this point. The track at the dam was raised twenty feet higher than the old roadbed, the total excavation amounted to about 60,000 cubic yards, 80 per cent of which was solid granite. The change in roadbed alone cost $75,000, required one year to complete, and all work was done without interference with traffic, there being operated over this line an average of thirty to forty trains per day.

The dam is 540 feet long, 30 feet high, 43 feet 9 inches thick at the base, and 11 feet at the top. It is built of cyclopian concrete, the large stones in some instances approximating five cubic yards. Approximately 22,000 barrels of cement were used in construction of dam, foundation of power plant, and retaining wall for the protection of the roadbed. The downstream face of the dam is curved in such a manner as to insure the water always clinging to the surface and preventing the formation of a vacuum under the falling sheet, since it is generally conceded by engineers that a vacuum on the downstream side is responsible for the trembling often felt in the vicinity of overfall dams.

There are two 7-foot mud gates in the dam next to the power house, which are operated by hydraulic cylinders and are opened and closed by an electrically driven pump in the power house. The gates and cylinders are entirely submerged.

The four penstock gates are among the largest cast iron gates made; each gate covers a clear opening of 18 feet by 7 feet 3 inches and weighs thirteen tons. They are operated in pairs by an electric motor.

The power house, 40 by 76 feet, fireproof throughout, is built of concrete to the floor line, and of brick from that point up. Windows are of steel and prismatic glass. The height from floor to eaves is 31 feet; from the bottom of the foundations to the comb of the roof 100 feet. A fifty ton electrically operated traveling crane extends through the entire length of the building.

The equipment consists of two 1875-kilowatt three-phase Westinghouse alternating-current generators, working at 6,600 volts, 60 cycles and 133 R. P. M. Each is directly coupled to two turbines. The units are vertical, with the exciters located on top of the generators. The current, generated at 6,600 volts, is stepped up to 66,000 volts for transmission. The entire control of the plant is from the switchboard, all gates, switches, motors and valves being electrically operated.

Duplicate power lines have been built on private right of way, one on the west, the other on the east side of the river, to a second plant owned by the same company, and situated six miles northwest of Asheville, where there is a substation for distributing the power to Asheville, Canton and other places.

The Application of Pyrophoric Alloys

Their Use Extends from the Pocket Cigar-lighter to the Miner's Safety Lamp

Although a great variety of applications was predicted for metallic cerium, it is at present employed almost exclusively, in the form of its pyrophoric or spark-forming alloys, in the production of "flints" for cigar lighters, gas lighters, and other ignition apparatus. The demand for this purpose has increased enormously, especially during the past year, in which the world's consumption of the pyrophoric alloys may safely be estimated as 8 or 10 tons, practically all of which was used for flints, weighing 1,500 or 2,000 to the pound. About half of these went to replace worn-out flints; the remainder was used in new igniters, of which 10 to 15 millions were made last year.

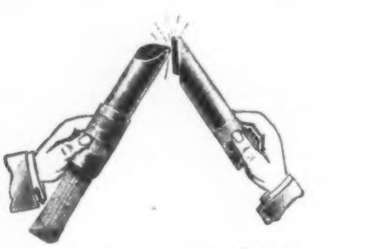


Fig. 1.—Cerium Flint and Steel.

Imperfect construction of apparatus, lack of permanence of the alloys and the high price of both, retarded the general introduction of the cerium igniters but these obstacles have been overcome so successfully that the new device threatens the match industry with formidable competition, especially in Germany, where a heavy tax was imposed on matches last year. The match makers demanded the imposition of a corresponding tax on the cerium igniters but were pacified by a concession and so the development of the new industry was left unhampered.

In normal conditions each flint will give from 2,000 to 6,000 ignitions, according to its size and hardness. But alloys which are quite permanent in the air are quickly destroyed by acids, saline solutions and even pure water. Dr. Hennig, in an article in *Prometheus* which is here summarized, cites the case of a cigar lighter in which the flints became useless in a few days because the cotton wool employed as an absorbent of benzine was thoughtlessly put into the apparatus before the latter was nickel-plated and hence became contaminated with acid.

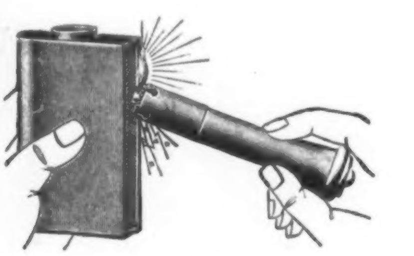


Fig. 4.—Striking Lighter.

The varieties of ignition apparatus employing pyrophoric alloys are counted by hundreds, if not thousands. A few of the principal types are here described and illustrated.

In the earliest and simplest of these devices (Fig. 1) a wick or fuse containing saltpeter is ignited by sparks produced by striking a cerium alloy "flint" with the sharpened and hardened edge of the tubular steel fuse-holder. This apparatus has retained its place on the market because of its efficiency in windy weather.

Fig. 7.—Candle-shaped Lighter.

The most extensively used apparatus is the automatic pocket cigar lighter, made in the form of a match box (Fig. 2). When a button is pressed the cover flies open and sets a rotary file into rapid rotation. The flint is pressed against the file by a spring and the sparks produced by the friction fall on and ignite the wick of a little benzine lamp. Some automatic cigar lighters have a fuse in place of, or in addition to, the lamp, and some of the newer models are made in the form of a watch case.

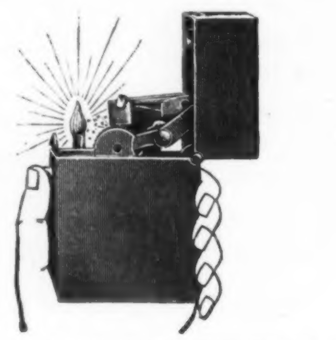


Fig. 2.—Automatic Pocket Cigar Lighter.

Another type, in which the turning of a handle first opens the lid and then moves a straight file in contact with the flint, is shown in Fig. 3.

Fig. 5.—Wall Lighter.

"Striking" lighters of the type illustrated in Fig. 4 have lately become very popular. The flint is mounted like a crayon in an adjustable holder and is surrounded with asbestos. The flint holder, when not in use, is inserted in the box, where the asbestos is in contact with a mass of cotton saturated with benzine. When the flint is rubbed on a flat file attached to the side of the box the sparks ignite the benzine absorbed by the asbestos, and the fuse-holder becomes a diminutive torch. Striking lighters are also made with feet, so that they stand securely on a table, or are arranged to hang on a wall (Fig. 5).

Another form for table use is illustrated in Fig. 6. It consists of an automatic lighter (Fig. 2) mounted removably on a stand which serves also as an ash receiver and has a cigar clipping attachment.

Fig. 7 shows a combined cigar lighter and ash receiver in the form of a candlestick. It is operated by moving a handle and thus comprising and releasing a spring which turns a rotary file against a flint and ignites a wick saturated with benzine.

Although the pyrophoric alloys produced are used chiefly in pocket cigar lighters, gas lighters are also made in large and rapidly increasing numbers, and in great variety. Most of these are of the general type illustrated in Fig. 8, resembling tongs in appearance and to some extent in operation. When the legs are pressed together, and also when they spring apart on being released, a file attached to one leg rubs against a piece of pyrophoric alloy attached to the other leg, producing sparks which light the gas jet over which the instrument is held.

There are also numerous gas lighters of the pistol type, illustrated in Fig. 10. A spiral spring, connected with a rod which carries a file at its upper end, is compressed by pulling a trigger, and when the trigger is released the file is shot upward, producing a copious shower of sparks by friction with a cerium "flint" pressed against it.

In addition to these portable gas lighters, devices designed to be attached to gas fixtures are now to be had. A lighting attachment for an erect incandescent burner is illustrated in Figs. 9 and 11. An auxiliary jet is connected with the gas pipe, below the burner, through a valve which after the gas has been turned on, is opened by pressing the toothed wheel inward, as the arrow indicates. Then by turning the handle a rotary file is caused, by means of the wheel and pinion, to revolve rapidly in contact with a cerium flint, lighting the auxiliary jet which in turn lights the main burner. When the handle is released the wheel automatically moves outward, closing the valve and extinguishing the auxiliary jet. The lighting attachment for inverted burners is placed above the burner, into the top of which the auxiliary jet is directed downward (Fig. 12).

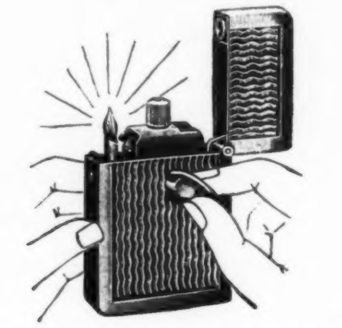


Fig. 3.—Pocket Lighter With Handle.

The makers of miners' safety lamps are now showing keen interest in the pyrophoric alloys. The first lamps employing these alloys were evidently failures, for their use was prohibited. It is asserted that the glowing metallic particles escaped through the wire netting into the atmosphere of the mine and thus formed a possible cause of explosions. Moreover, unburned particles of the cerium iron alloy were scattered through the interior of the lamps where they might subsequently become ignited by contact with the hot netting and cause perforation and explosion in an atmosphere of fire damp.

Fig. 6.—Universal Lighter.

Apart from these defects, ignition by pyrophoric alloys possesses very great advantages over the usual methods of ignition with paper strips of fulminating caps exploded by friction or percussion, and over the newer paraffin

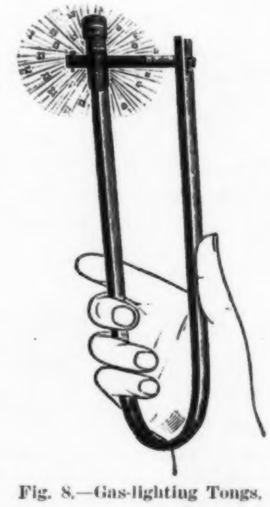


Fig. 8.—Gas-lighting Tongs.

friction devices. The alloys produce no deposit on the lamp chimneys, thus assuring a bright light and diminishing the cost of cleaning. As each flint suffices for thousands of ignitions the chance of a flint becoming exhausted during a working shift is negligible. The aboli-

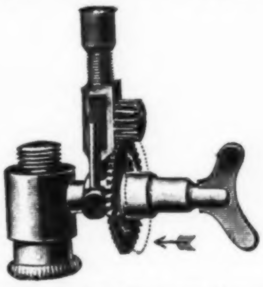


Fig. 9.—Gas-lighting Attachment.

tion of explosive caps would save time, labor and expense, and would greatly lessen the danger of fire in the lamp rooms.

The removal of the defects of the pyrophoric method, therefore, has been an object of diligent endeavor. The Koch Company has replaced the cerium iron alloy by another pyrophoric alloy, presumably Kunheim metal, which does not project far-reaching sparks but produces an almost continuous sheet of flame adhering closely to the metal, from which very few unburned particles fall. Furthermore, the Koch apparatus is so constructed that the compact bundle of sparks is projected entirely upon the wick by a sheet guard over the flint, so that nearly all of the metal particles are consumed in the flame. The file is very fine, so that the metal particles are neither coarse nor excessively numerous. The flint is a rod of alloy about 3/5 inch long and 1/6 inch thick. It is inclosed in a brass tube which wears down with it and protects it from weathering and crumbling at the edge. The

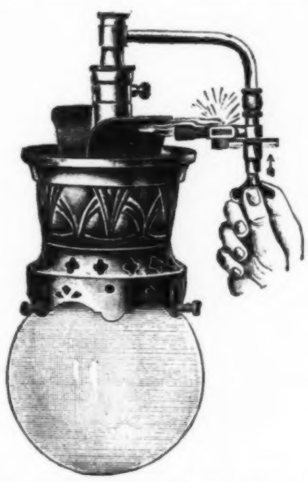


Fig. 12.—Inverted Burner With Lighting Attachment.

apparatus is contained in a flat cylindrical case which is simply set on top of any lamp in which paper strips of explosive caps can be used. Fig. 13 shows a horizontal and a vertical section. The tube *a* contains the flint and its feeding spring. By turning a shaft which projects outside the lamp the lever *f* is caused to move the steel file *b* backward along its guide slot *c*, compressing the spring *g* which, when the lever passes the peg *d*, drives the file forward, in contact with the flint, producing a compact sheaf of sparks which ignites the benzine-saturated wick. This apparatus and an "erect" ignitor made by the same firm for lamps designed for paraffin friction

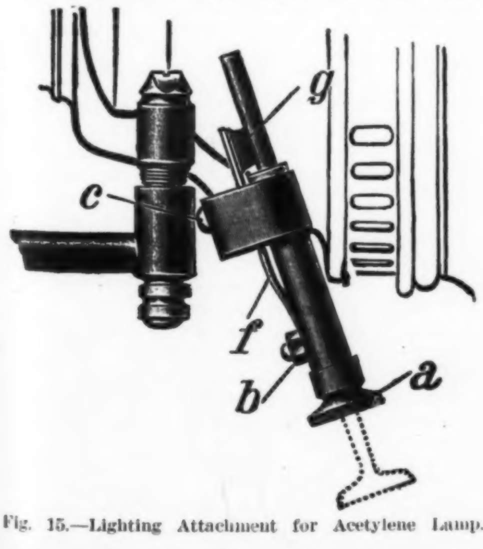


Fig. 15.—Lighting Attachment for Acetylene Lamp.

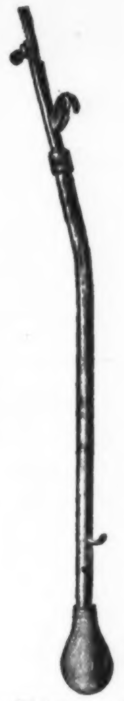


Fig. 10.—Pistol Gas Lighter.

ignition, have been found both reliable and safe. More than 20,000 Koch safety lamps had been delivered to mining companies a year ago.

The form designed to replace the paraffin friction ig-

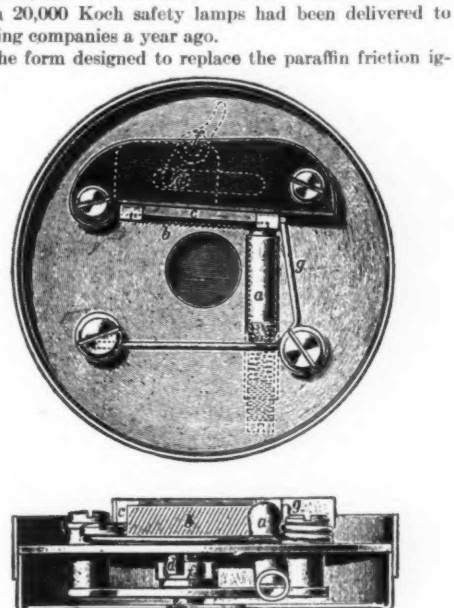


Fig. 13.—Koch's Lighting Attachment for Miners' Safety Lamps.

niter, for which it can be substituted without altering the lamp in any way, is illustrated in Fig. 14, which shows its three principal parts, separately and in combination. The housing *a* contains the flint *b* with its spring, and the locking pin *c*, with its spring. The shaft *d*, turned by the handle *g*, bears at its top a collar *e*, having a spiral groove and a tooth projecting upward. Below the collar are incisions *f* with which the pin *c* engages. The pivot *h*, which sets loosely in the hollow upper part of the shaft, carries a grooved collar *i*, which has a tooth projecting downward. Above the collar are the spring *k*, the file wheel *l* and the nut *m*. Quick action is assured by a guide fork placed outside the housing with its ends in the grooves of the collars *e* and *i*.

When the handle *g* is turned, the spring *k*, one end of which is fastened to the housing, is coiled up until, by means of the curve of the collar *e*, the pivot *h* is lifted and freed from the shaft.

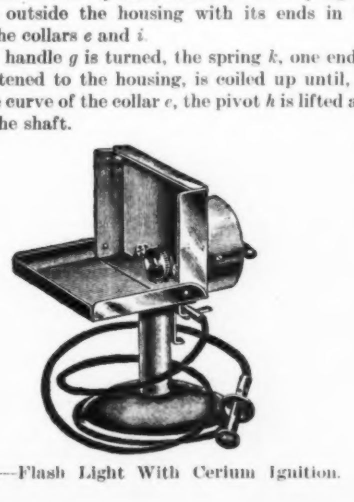


Fig. 16.—Flash Light With Cerium Ignition.

The file wheel then flies round suddenly through a small angle, producing a small compact bundle of sparks by friction with the flint. A rod of alloy 2/5 inch long and 1/8 inch thick yields at least 2,000 ignitions.

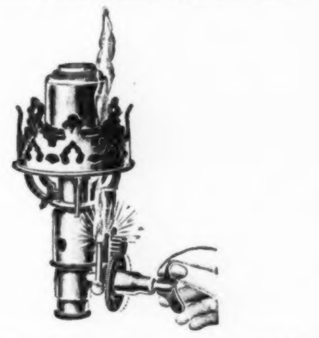


Fig. 11.—Incandescent Burner With Lighting Attachment.

Pyrophoric alloys can also be employed for lighting acetylene automobile and bicycle lamps. A very practical apparatus, which is permanently attached to the lantern and can be used without opening the latter, is illustrated in Figs. 15 and 17. The flint *g* is attached by a flat spring *f* to the outside of the tube *b*, which contains a steel rod *a*. When the rod is drawn downward, as the dotted lines indicate, and then released, it is violently retracted by a spring and its upper part, which is roughened and hardened, rubs upon the flint. The tube *b* and the

Fig. 14.—Fremann and Wolf's Lighting Attachment for Miners' Safety Lamps.

spring *f* are inclosed in a short oval tube, which gives support to the spring, and the oval tube is surrounded by the sleeve *c* which is fitted to an opening in the lantern.

Although the cerite alloys have not attained the great importance in photography which was predicted, they have been found useful for igniting flashlight powder. The simple and practical apparatus shown in Fig. 16 consists of a pan mounted on a stand and provided with a vertical screen, which carries a pyrophoric flint and a file wheel, pressed together by a spring. The driving spring and winding key are at the back of the screen.

When the spring is released, the file wheel is thrown into rapid rotation, producing a shower of sparks which ignite the flashlight powder strewn on the pan.

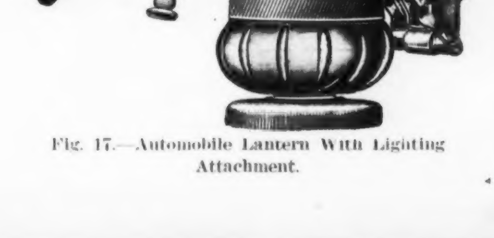


Fig. 17.—Automobile Lantern With Lighting Attachment.

The Production and Identification of Artificial Gems—I.*

How They Are Made, and How Distinguished from the Real

By Noel Heaton, B.Sc., F.C.S.

DURING recent years the production of artificial gems on a commercial scale has become an accomplished fact, and a great many misconceptions and misleading statements have been made as to the relation which these productions bear to natural products on the one hand and imitation gems on the other. It may therefore be of some use to make the matter clear by describing as fully as circumstances permit what has been done in this direction and what has not been done; what is practicable and what is impracticable in the present state of our knowledge.

I suppose there are few subjects of interest from so many points of view as that of precious stones. The beauty and rarity of fine specimens has from time immemorial rendered them the most treasured of possessions. With the romance that surrounds this aspect of the question we have nothing whatever to do to-night, except to bear in mind that on account of their great value men have for centuries strained their ingenuity to solve the mystery that surrounds the origin of such stones, and to amass wealth by producing them at will instead of by the laborious and highly speculative process of digging for them.

Until the development of modern science and accurate methods of investigation, this problem resisted all attempts at solution, and it is, in fact, only within the last few years that the artificial production of any species of gem on a commercial scale has become practicable.

Of course, one can cut the Gordian knot by preparing a colorable imitation of the real thing, but that is quite another matter, and I want to make it quite clear, at this point, that I propose to limit the term "artificial" to such productions as possess the same chemical composition and physical constants as the natural stones, differing from them only in minute details consequent upon their being produced in the laboratory instead of being dug out of the earth; all other makeshifts being properly described as "imitations." The production of *imitation* gems is by no means a modern invention, as is doubtless well known to you. To go no further back than the time of the Roman Empire, the master glassmakers of the dawn of our era, whose skill and knowledge of glassmaking one appreciates more highly the more one investigates the industrial life of those times, were able to imitate almost any precious stone exactly, as far as outward appearance went, in colored glass—and not only the transparent gems, but the structure of such semi-precious stones as agate, cornelian, lapis, and porphyry. It would be quite out of place to devote any time to-night to this historical aspect of imitation gems, but I cannot refrain from alluding to the remarkable examples of such imitations found by Mr. Woolley at Karanog,† from which it is difficult to resist the conclusion that in quite early times Nubia was the center of this industry. To judge by the stories one reads about jewels in those times—stories of the Emperor Comnenus, for example—one suspects that the glassmakers turned their skill in this direction to some account and considerable profit on behalf of an ignorant and somewhat credulous aristocracy; for in those days, and, in fact, until quite recently, not only was the nomenclature of gems very vague, but methods of identification were chiefly remarkable for their non-existence.

The chief criterion of a precious stone was its color, so much so that throughout medieval times blue glass was known as sapphire and green glass as beryl, etc., giving rise to the legend that in the time of Queen Elizabeth windows were glazed with sheets of beryl.‡ As the tendency still lingers to regard all red stones as rubies and green as emeralds, and so on, I would like to make it clear at this point that color is really quite an accidental property of precious stones: the substance of which nearly every species of transparent gem is essentially composed is colorless, and the color is really produced by minute proportions of impurity.

This being the case, we find that on the one hand the same species of gem may exist in a large variety of colors, and on the other hand that a color characteristically associated with one gem may often be found in another having essentially different composition and properties. Owing to this confusion it was very difficult to draw the line between a genuine and imitation stone until the various species of gem stone were accurately defined and their names clearly associated with particular composition and properties, the determination of which forms, at the present time, a means of distinguishing one from another, and also of deciding whether an alleged gem is genuine or imitation with ease and certainty.

The scientific examination and identification of gems in this manner is a matter of the greatest interest, but it would take far too much time to discuss it in detail. I propose, therefore, merely to remind you of the main points by the following summary:

Table I.
Properties Influencing the Value of Precious Stones and Used as Means of Identification.

Beauty	Color.	
	Structure	Cleavage.
		Lamination.
		Inclusions.
	Optical properties	Refractive power [Refractometer].
		Double refraction [Polariscope].
		Pleochroism [Dichroscope].
		Dispersion.
		Absorption spectrum [Spectroscope].
Durability	Hardness [Hardness points].	
	Toughness.	
	Chemical composition.	
Additional means of Identification	Specific gravity.	
	Thermal conductivity.	
	X-rays.	

The most important properties of a precious stone are those depending upon its refractive powers. Until recently the accurate determination of the refractive index of a stone was a matter involving the use of complicated and expensive instruments, and a matter for the skilled mineralogist rather than the practical jeweller. Thanks to the ingenuity of Dr. Herbert Smith, the Reflectometer has now been improved out of all recognition, and in its place we have the Herbert Smith Refractometer (Fig. 1), by means of which

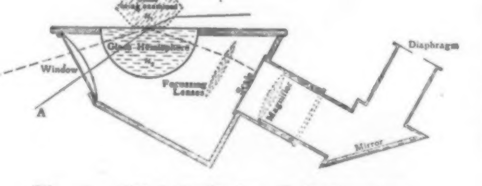


Fig. 1. Total Reflection Refractometer.

anyone of normal common-sense can determine the refractive index of a stone in a few seconds without even removing it from its setting, and which, with a little practice, will also enable one to determine with similar ease the amount and kind of double refraction and the degree of dispersion.

As will be seen from the diagram, the main principle of the instrument is the same as that of the reflectometer, the refractive index being measured against a standard of highly refracting glass by means of the angle of total reflection, which of course diminishes, the nearer the index of the stone approaches that of the standard. It is, however, in the details of construction that such a marked advance has been made, and it is these details which make all the difference in practical work. To use this instrument all that has to be done is to place the stone under examination in optical contact with the flat surface of the dense glass, and arrange it so that a good light (preferably monochromatic) enters the instrument through the lower lenticular opening, when the refractive index is read off directly on a scale, without calculation.*

Some little advance has also been made in the construction of the Dichroscope for determining pleochroism. The instrument in use to-day is provided with a revolving holder tipped with wax, to which the stone is readily fixed, leaving both hands free. A detail, but again it is such details that count in practice.

Taking the properties of precious stones as a whole, the great point about them is the remarkable combination of qualities; it is not so much that they have optical properties which make them extraordinarily beautiful, or that they have remarkable hardness and durability, but they have *both*, and it is the impossibility of reproducing this combination in any other material that renders the detection of imitations a matter of ease in the hands of anyone familiar with the facts.

Of course, glass is the obvious material to use in the production of imitation gems, and, as I have indicated, it has been so used from time immemorial. And, in later times, while science was equipping the expert in precious stones with the means of identifying them with certainty, the maker of imitations was also invoking its aid in the production of more successful imitations.

In modern times the manufacture of imitation gems on scientific lines was introduced by Strasser in Vienna; hence the name "strass," although "paste" is the more commonly used term.

The finest of such modern paste bears little relation if the clumsy imitations of early times; the glass is specially prepared in order to combine, as far as possible, the necessary optical qualities with a fair amount of durability. It is well known that by using lead instead of lime as the basic constituent, the refractive index and dispersive power of glass are much increased, and by replacing the alkaline constituent by thallium oxide in the same manner the refractive index may be raised as high as 1.96 and the dispersion to 0.049.* By adjusting the composition in this way, and preparing the glass with the greatest regard to the purity of the materials, manipulating it, moreover, in a similar elaborate manner to that employed in the production of glass for optical instruments, in order to secure the utmost freedom from striation and inclusions, it is possible to imitate any precious stone accurately, as far as outward appearance is concerned.

The trouble is, however, that with glass the more you increase its refractive power in this way the softer and less durable it becomes, until you find that the very "dense" flint used for the refractometer, having a refractive index of 1.8049, is so soft that it has to be handled with great care to avoid scratches, and so little resistant to decay that in a comparatively short time the exposed surface becomes corroded, which is the one weak point in this instrument. It is true that this softness may be counteracted to some extent by further adjustment of the composition, adding a proportion of alumina and zinc, and by careful thermal treatment of the finished stone in some such manner as that originally introduced by Bastie, in which the glass is case-hardened by plunging while hot into a bath of oil. In some of the best modern paste I have found a refractive index of over 1.6 combined with a hardness close on that of quartz, but this is the absolute limit, and it is not possible in any way to obtain a paste that cannot be scratched with a hardened steel point. Paste can also be readily identified by means of the scientific tests, as indicated in Table II.

TABLE II.
IDENTIFICATION OF IMITATION GEMS.

PASTE.	STONES.
Index of Refraction rarely exceeds 1·69.	Index of Refraction ranging up to 2·4.
Single Refracting, or false double Refracting owing to strain.	Double Refracting, with exception of Diamond, Garnet, and Spinel.
Never Pleochroic.	Often strongly Pleochroic when coloured.
Hardness always below 7.	Hardness 7 or over (with a few exceptions).
Specific Gravity usually above 4.	Specific Gravity usually below 4.
Thermal Conductivity low.	Thermal Conductivity comparatively high.
Opaque to X-Rays.	Translucent or transparent to X-Rays.
Generally show spherical bubbles and curved striae.	Frequently show lamination or inclusions.

The most important point to remember about paste, however, is its lack of durability; it is not only too soft to stand much wear, but its composition is so unstable that it rapidly deteriorates and loses its brilliancy on exposure. You will see, therefore, that although there is a certain legitimate scope for such paste imitations they are very unsatisfactory substitutes for the genuine article. This being the case, as scientific knowledge has advanced, attention has been more and more concentrated on the problem of producing by artificial means the actual minerals found in nature, and thus obtaining what I have defined as artificial in contradistinction to imitation jewels, having both the beauty and durability of the natural article without the objectional concomitant of enormous cost.

* Paper read before the Royal Society of Arts.

† "Karanog," by C. L. Woolley and D. Randall, MacIver: Philadelphia Museum, 1910.

‡ This is quoted in Hollingshed. We read in Theophilus (II., Cap. xii.) of "tabulas saphiri pretiosas ac satis utiles a fenestris."

* It is impossible here to give any detailed account of the construction and use of this instrument. Full particulars will be found in "The Herbert Smith Refractometer," published by J. H. Steward, 406, Strand.

* These are the constants given for the Jena glass, No. S. 57: the specific gravity is 6.33. Refractive index of diamond is 2.4, and dispersion 0.057.

The first point to be considered in attacking this problem is the composition of the stone, as it is obvious that, other things being equal, the possibilities of success are greater with one of simple than one of comparatively complicated composition. One also has to consider, however, the economic aspect—it is not much use devoting time and ingenuity to the production of an artificial stone when the natural one is so common that the cost of the two would be practically identical.

Taking these two points in conjunction, and confining our attention for the moment to the transparent stones as summarized in Table III, the diamond appears to offer the most promising field for attack and corundum comes next, and we find that the main attempts at artificial production center round these species. From the point of view of composition alone, quartz is the most simple, but it is so common in nature as to render its artificial production scarcely worth while. The aluminate group offers some attraction, but the artificial production of crystalline silicates on a large scale is a very difficult problem, and, with the exception of the emerald, the stones comprised in this group are so freely distributed in nature as to render their artificial production a matter of academic rather than industrial interest.

TABLE III.
COMPOSITION OF THE PRINCIPAL PRECIOUS STONES.

	SPECIES.	VARIETY.	COMPOSITION.
ELEMENT	Diamond	—	Carbon.
OXIDES	Corundum	Ruby. Sapphire. Oriental Amethyst, etc.	Oxide of Aluminium.
	Quartz	Crystal. Amethyst. Cairngorm, etc.	Silica.
ALUMINATES	Spinel	Balas Ruby, etc.	Magnesium Aluminate.
	Chrysoberyl	Cymophane. Alexandrite	Beryllium Aluminate.
SILICATES	Beryl	Emerald. Aquamarine	Beryllium Aluminium Silicate.
	Garnet	Hessonite.	Calcium Aluminium Silicate.
		Pyrope	Magnesium Aluminium Silicate.
		Almandine	Iron Aluminium Silicate.
		Demantoid, etc.	Calcium Iron Silicate.
	Olivene	(Peridot)	Magnesium Iron Silicate.
	Sphene	—	Calcium Titanium Silicate.
	Spodumene	(Kunzite)	Lithium Aluminium Silicate.
	Topaz	—	Aluminium Fluo-Silicate.
	Tourmaline	—	Complex Alkali-Lime-Alumina Silicate.
	Zircon	Jargoon. Hyacinth	Zirconium Silicate.
	Turquoise	—	Hydrous Aluminium Phosphate.
	Opal	—	Hydrous Silica.
	Pearl	—	Calcium Carbonate.

It is unnecessary to discuss at any length the artificial production of the diamond*—the problem has been attacked by numerous scientists, and was solved by Moissan some years ago. Some fifteen years ago, on the occasion of a visit to Paris, I had the privilege of witnessing the production of his diamonds, prepared, as all the world knows, by saturating iron with carbon at the temperature of the electric arc and plunging the molten mass into cold water. The mass of iron is then dissolved in acid and the residue subjected to a laborious process of extraction, the diamonds being picked out by aid of the microscope. The largest diamond that has been produced in this way is barely visible to the naked eye, however, and when I say that the problem of their production has been solved, I mean especially from the scientific point of view.

*A complete account is given in "Diamonds," by Sir William Crookes (Harper's Library of Living Thought).

The artificial production of the diamond is, in fact, far more complicated than it appears at first sight. If it were only a matter of obtaining the necessary high temperature to fuse the carbon to obtain it in the crystalline condition it would be simple—such high temperatures are readily obtained nowadays by means of the electric furnace and the oxy-acetylene flame—but carbon is one of those substances which pass direct from the solid to the gaseous state under ordinary atmospheric conditions, and only assumes the liquid condition under enormous pressure. The combination of high temperature and enormous pressure can be obtained momentarily by Moissan's ingenious process, but to obtain crystals of any size it is necessary to conduct the operation on a very large scale and to maintain the combined temperature and pressure for a sufficient length of time to allow the liquid carbon to separate out from its matrix; moreover, the entire operation must be conducted out of contact with air, for carbon rapidly combines with oxygen at high temperatures.

Commercially, we are as far from being able to produce artificial diamonds as in the days of the alchemists. It is, perhaps, a bold thing to say that no such thing as an artificial diamond will ever be placed on the market, but one can safely assert that so far as our knowledge stands at present it is impracticable. In saying this, I am quite aware that statements as to the commercial production of synthetic diamonds being an accomplished fact have quite recently appeared broadcast in the public press, but those who are responsible for such statements are, shall we say, under a misapprehension as to the meaning generally conveyed by the term "synthetic," and are unable to follow the distinction I have drawn between an artificial gem and an imitation.

To pass on to corundum, the problem of its artificial production is very much simplified by the fact that its composition is oxide of aluminium, and alumina—which is, therefore, its amorphous equivalent—fuses to a liquid under ordinary atmospheric pressure at a temperature somewhere about 2,000 deg. C. (the exact point has not as yet been determined), and being the only stable oxide of a strongly basic metal, it can be heated in air without any change.

The chief problem to be faced, therefore, is that of attaining the necessary temperature, and it is not surprising that crystalline alumina was produced as a scientific curiosity as far back as the commencement of the nineteenth century. It is at this time that we first begin to hear of the oxy-hydrogen blowpipe (or the gas blow-pipe as it was then called), and in a book published in 1819,* describing various experiments with this new apparatus, we read that "two rubies were placed upon charcoal and exposed to the flame of the gas blowpipe . . . after suffering it to become cold . . . the two rubies were melted into one bead." This hint does not appear to have been followed up for some considerable time, however, and the earlier experimenters in the production of artificial gems worked in another direction; they were unable to obtain products of commercial utility, because although they succeeded in obtaining crystalline alumina, it was produced under conditions which resulted in the formation of a mass of small crystals, almost microscopic in size. Moreover, the form of these crystals was that of the hexagonal plate which is the fundamental form of corundum, and such a form would be useless for cutting even when of considerable area, owing to its thinness. Thus Gaudin, who appears to have been one of the first to attain any success in this direction, obtained a mass of such crystals by fusing alum and potassium sulphate in a closed crucible. Ebelman obtained similar results by fusing alumina with borax, and later Deville and Caron used aluminium fluoride and boric acid. All these attempts yielded similar results, as in each case fusion was obtained by the air of a substance melting at a lower temperature which acted as a solvent. Consequently the alumina crystallized out in much the same manner as a salt crystallizes from a saturated solution, and to obtain sufficiently large crystals to be of practical use it would be necessary to conduct the experiment on a very large scale, and subject the fused mass to very slow and carefully-regulated cooling.

*"The Gas Blowpipe, by Dr. E. D. Clarke.

In 1877 Fremy and Feil attempted to get over this difficulty by using lead oxide as the flux and employing a crucible composed of highly-acid clay. On heating up the mixture in such a crucible the lead oxide melts and combines with the alumina to form lead aluminate, and on further heating this reacts with the silica of the fire-clay, forming lead silicate and setting free the alumina, which crystallizes out. But although very much larger crystals were obtained by this ingenious process they had the same form, and were too thin for industrial employment.*

Some time earlier than this, however, we hear of the oxy-hydrogen blowpipe again, for Gaudin had noticed (as Clarke did in 1819) that by introducing alumina into the flame of an oxy-hydrogen blowpipe he could obtain globules of fused alumina similar to the borax beads one makes in the ordinary blowpipe. Gaudin appears to have taken it for granted that these beads were amorphous—that is, an alumina glass—and it was not realized until many years later that they were really identical in all their properties with natural crystalline corundum. When this was realized, the commercial production of corundum became only a matter of detail.

Having obtained this further point, the idea immediately suggests itself of converting small and useless stones into valuable gems by fusing them together into one, and, as a matter of fact, "reconstructed rubies"—as stones produced by this method are now generally called—made in this manner were the first artificial gems to be prepared on a commercial scale. These were introduced some quarter of a century ago under the name of "Geneva rubies," and were offered as, and realized the price of, natural stones, until the method of their production became apparent.

To be continued

* For a full account of the history of these earlier attempts see "La Synthèse du Rubis," by F Fremy, 1891.

The Uncovering of Herculaneum

THE excavations at Herculaneum were discontinued in 1780 owing to the spreading of the town of Retina, which is built over the ancient site, and the work could go no further on this account. The area now excavated is small, and is limited to a space traversed by an ancient street bordered with the remains of houses. But even from this limited space were taken the objects which are now in the Naples Museum, especially the bronzes which are so much admired and which give evidence of the superiority that Herculaneum has over Pompeii in artistic riches. Unfortunately there are several obstacles which prevent uncovering the site of the ancient city to bring to light its buried treasures. A town of 30,000 inhabitants lies over the site, to begin with. Another obstacle lies in the fact that owing to national pride, Italy does not wish the honor of uncovering Herculaneum to go to any other nation. Still another point which causes much discussion among scientists, is the composition of the volcanic covering and the means of removing it without complications or great expense. This last problem needs to be solved in the first place before coming to the two others.

Prof. G. di Lorenzo of the Naples University has been occupied with the question, and his opinion has much weight as he is a leading geological authority. The ground under which the ancient city is buried and carrying the town of Retina forms a small valley bordered by ranges of hills on several sides and on the west by the sea. The hills or rocks are of recent formation, being composed of lava coming down from Vesuvius in 1631 with such great speed that it reached the sea in not more than an hour. The present appearance of the valley is thus different from what it had been in ancient times. Strabo and other ancient authors state that Herculaneum was situated on a promontory lying between two rivers and was at 60 feet above the level of the sea. At present, the city lies no less than 60 feet below the present level of the new town. Prof. di Lorenzo considers that the only possible way will be to run underground tunnels starting from the already-opened area. But a scientific theory has been opposed to this enterprise up to the present, this being the hypothesis of two kinds of lava. What was done at Pompeii could not be carried out at Herculaneum, not only on acount of the new town, but also from the different structure of the lava in the two cases. While Pompeii was covered by a cinder layer, the other city was buried under a layer of mud, and this became so hard that it is now very difficult to cut or blast. However, several objections can be made to this old theory. As the city lay on a promontory, it is natural that the mud torrents flowed rather in the two river beds at its sides. Besides, an abundant rain would be necessary to make such mud torrents flow, and none of the ancient writers mention any rains which were produced at the beginning of the eruption. On the contrary, what makes it probable that both Pompeii and Herculaneum were covered by the same kind of deposit is the letter addressed by the younger Pliny to Tacitus, stating that his uncle, the elder Pliny, after observing the gigantic smoke column in the shape of a pine tree at the beginning of the eruption and hearing of the critical situation of the sailors in the port of Retina, this being the port of Herculaneum (the new town now lies back of this site), fitted out a number of vessels and proceeded to this port. But he could not land on account of the ash and other volcanic matter of all kinds, which were highly heated and fell thickly upon the sea, even then raising the sea bottom, so that he was obliged to land at another point. Pliny mentions numerous kinds of dry matters, but makes no allusion to a rain which would be needed to make a flow of mud. A geological examination of the ground of Herculaneum shows besides that it is made up of a thick layer of volcanic ash of the nature of pumice stone and is quite the same as the deposit of Pompeii in its composition. Only the higher region of Herculaneum shows layers of mud deposit due to alluvium which was afterwards formed by rainfall, and this gives a soil of another structure. Another objection given by the old theory seemed to be conclusive, that is the difference in the patina of the bronzes coming from the two cities, but Prof. di Lorenzo gives the following explanation: The patina of the bronzes found in the 18th century is lacking from the fact that the objects were cleaned and varnished. Recent bronzes have their patina, which is green at Herculaneum and blue at Pompeii. The deposit at this latter site were less dense, and the water passed through freely, giving a deposit of blue carbonate of copper on the bronzes. The contrary is true for the other site, and the water filtered through much more slowly, so that it gave rise to a green carbonate. To conclude, if it is proved that the material which covers the two sites is of the same composition and this idea becomes general, there will not be the same obstacle towards making the excavations and these can be carried on underneath the town of Retina without any special difficulty.

Natives "Skipping the Rope" in the Arctics.

Group of Eskimos Who Had Never Seen a White Man Before.

A New People in Arctic America

Discovery of a Tribe of Seemingly Scandinavian Origin

By W. Beasley

Some interesting and valuable results have just been announced by the Arctic Expedition sent out in charge of Messrs. V. Stefansson and R. M. Anderson, under the auspices of the American Museum of Natural History, with whom the Geological Survey of Canada also co-operated in some degree. This expedition left New York in 1908, to investigate the Eskimos, both west and

Eskimo of the Newly Discovered Tribe. (Note the Scandinavian Type.)

east of the Mackenzie River, especially those to the east, where, in the region of the Coppermine River, there are certain little-known tribes which invited closer investigation.

Aside from numerous and important surveys made of rivers and unexplored land areas, the most noteworthy anthropological find was the discovery of a hitherto unknown and new Eskimo tribe who had never seen a white man before. The accompanying photographs are the first to reach civilization and depict scenes among these isolated dwellers of the Arctic. The new people are described as "North European or Scandinavian-like in appearance" and were found in Victoria Land, hitherto thought to be uninhabited. It is now supposed that its population will reach nearly 2,000. Unusual interest is centered in the remarkable Eskimo tribe discovered by Mr. Stefansson. In May, 1910, these Eskimos, who had never seen a white man before, were discovered in their winter home out approximately half way between Dolphin and Union Strait, Victoria Land. The first encounter with this tribe is graphically described by the explorer. "Through neglecting the conventional peace signal of the Central Eskimo (extending the arms horizontally) our messenger, who preceded us by a few hundred yards, came near being knifed by the man whom he approached, who took his attitude (the arms down) for a challenge or rather a posture of attack. After the first parley however, everything was most friendly, and we found them the kindly, courteous and generous people that I have everywhere found the less civilized Eskimo to be. We were fed with all the best they had, choice parts of freshly killed seals and huge musk ox horn flagons of steaming blood soup. There was no prying into our affairs or into our baggage; no one entered our house unannounced, and if finding us alone at home, the first visitor always approached our house singing so that we had several minutes warning of his coming. At this time they had not enough meat to give their dogs more than half-rations, yet ours never wanted a full meal, and our own days were a continual feast.

"There were thirty-nine individuals in this group, a small part of the A-ku-li-a-kat-tag-mi-ut. Neither they, nor their forefathers as far as they knew, had ever seen a white man, an Indian, or an Eskimo from the West. The territory of these people has been supposed by geographers to be definitely known as uninhabited. Their isolation has been complete and largely self-imposed because of their fear and distrust of white men, of Indians and of the Eskimo to the West. Of one thing I am glad, that I have had an opportunity to see that all the best qualities of the civilized Eskimo are found more fully among their uncivilized countrymen.

"On May 17th, 1910, we found a North European-looking people, the Ha-ne-rag-mi-ut of Victoria Land north from Cape Bexley. Their total number is about forty, of whom I saw seventeen, and was said not to have seen the blondest of the group. They are markedly different from any American aborigines I have seen. They suggest, in fact, a group of Scandinavian or North European peasants. Perhaps better than my characterization of them was that of my Alaskan Eskimo companion, who has worked for ten or more years on a whaling vessel: 'They are not Eskimo, they are fo'c'sle men.' Two of them had full chin beards to be described as light, tending to red; every one had light eyebrows; one—perhaps the darkest of all—had hair that curled slightly.

"The Eskimo physical type varies considerably from

Four-year-old Eskimo Girl and Boy Dressed in Caribou Skins.

Greenland to Siberia. It may be that all these variants are due partly to blood mixture, and that the earlier, purer type was more 'European' in character than we have been thinking. On the other hand, they may have direct admixture of European blood. In the dif-

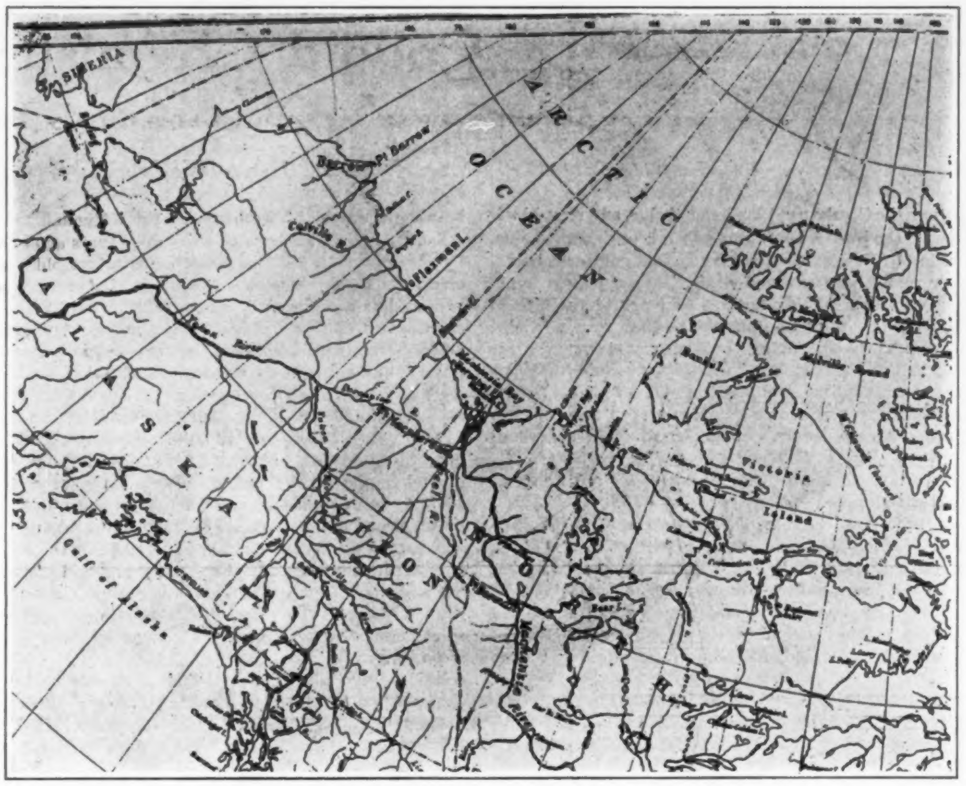
Explorer Stefansson With His Outfit Packed on Dog Sledge.

Putting the Dome on an Eskimo Snow House.

teenth century there disappeared from Greenland the Icelandic (Norse-teutonic) colony in its entirety. This colony had a bishop of the Church of Rome, two monasteries, a nunnery, fourteen churches and over three thousand inhabitants, who at one time sailed their own ships to Norway, to Iceland and to America. (Leif Ericson was one of these Greenlanders, and to the general public best known of them all). This colony was in a fairly prosperous condition as late as 1412, and we have Vatican documents of a later date referring to it; when Hans Egede came there in the seventeenth century he found only house ruins to tell the story, and no sure trace of Scandinavianism in the language or blood of the Greenland Eskimo. Either the colony had been massacred by the Eskimo, had disappeared through famine or pestilence, or had emigrated in a body. This last view many scholars have favored from the first, and if the people did emigrate, they may be represented in part by the present inhabitants of Victoria Land.

"Again, in the forties of the last century Franklin's expedition with its full complement of men was lost near the east coast of Victoria Land. Some of these men are accounted for by journal entries of officers who themselves later perished, and others by graves and unburied skeletons along the route toward Back's River. Franklin's men must have known there was a boat route to the Hudson Bay Company's posts on the Mackenzie River, for Franklin's own three expeditions had discovered and mapped it chiefly by boat voyages. Is it unlikely then that some of his men attempted this route? And even if they did not, might not a few of his men have found their way to the Eskimo of Victoria Land and have had sufficient adaptability to learn Eskimo methods of self-support? In regard to the possibility of Franklin's men having survived for a time, there is the interesting contributory evidence that there are at various places people said to be 'named with the names of white men.' One name in particular we have found in practically every community, 'Neck.' This is, at Herschel and farther west, the Eskimo pronunciation of the English 'Ned.'"

The Explorers, who are well equipped with food supplies, will remain in the field for another year owing to the fact that opportunities for ethnological study in this region are thought to be better now than they are likely ever to be again. When fully worked out the ethnological, archæological, and geographic results of the Museum's Expedition will greatly enrich our knowledge of the life habits, customs, etc., of some of the fast vanishing and most isolated races existing on the North American continent to-day.



Itinerary of the Stefansson Arctic Expedition.

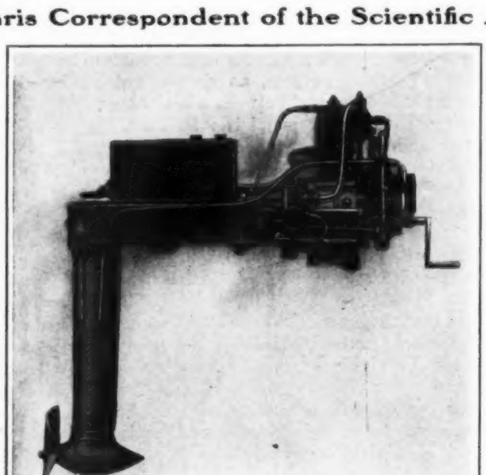
A Compact Launch Motor

The Propeller is Rotatably Mounted and Serves Also as Rudder

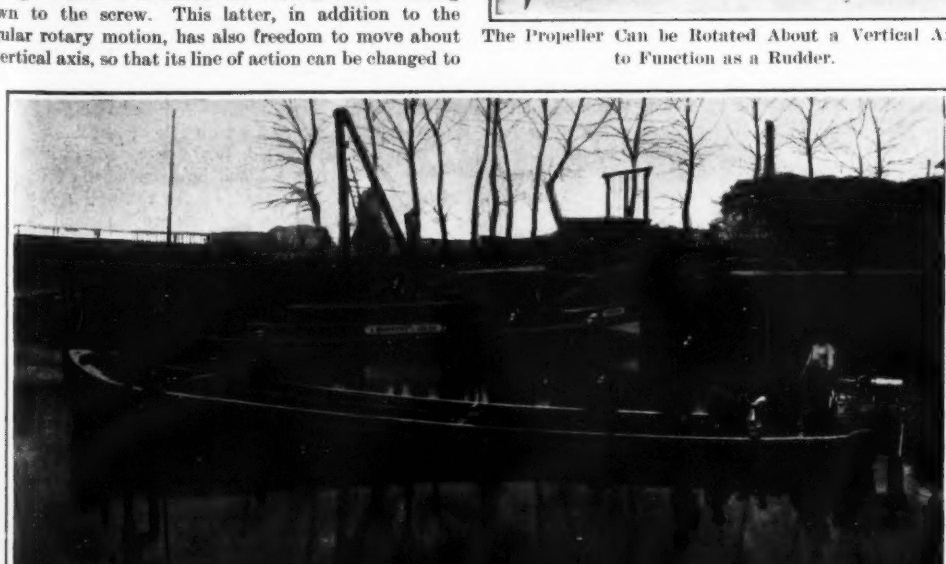
By the Paris Correspondent of the Scientific American

An interesting exhibit at the recent Paris show was the motor and propeller shown in our illustration. This is specially designed for small launches, and presents some original features. The chief aim has been to build the device as one unit, so that it can be readily and quickly mounted on any boat without making any material alterations.

Our illustration shows the gasoline motor, and the elongated casing which contains the transmission gear. This vertical casing extends down below the water level, and carries the screw propeller at its lower extremity. The parts can be quickly assembled, and the whole installed in the boat in short order. Any of the common types of motor can be used—gasolene, steam or electric. For use with an internal combustion motor, as in the arrangement here illustrated, a new carbureter is provided, which can be used with gasolene, alcohol or oil. The motor has direct drive on the horizontal shaft running aft. At the rear end this shaft engages a gear through which it actuates the vertical shaft running down to the screw. This latter, in addition to the regular rotary motion, has also freedom to move about a vertical axis, so that its line of action can be changed to produce a steering effect. For this purpose the screw is mounted in a separate casing rotatably attached to the bottom of the long vertical casing. The propeller casing is held in place by a long vertical rod extending up to the top, where it is geared to an inclined rod running to a hand wheel near the motor. By working the wheel the screw propeller can be turned at any angle to the axis of the boat, without interfering in any way with the regular running of the motor. To reverse the motion of the boat the propeller is simply turned through 180 degrees, without touching the motor. If the handwheel is completely let go the screw sets up a continuous rotation about its vertical axis, so that the motor can be allowed to run while the boat is stationary. Starting and altering the speed present no difficulty whatever. The "propulseur amovible," as M. Ducassou's invention is called, is made in various sizes from 4 to 40 horse-power and more. It has been adopted for small craft in the navy of several nations, among others of Russia, which has installed the device in the jolly boats of the gunboat "Krabry" and the battleship "Cesarewitch." Boats equipped with the Ducassou unit are also in use in the French, Brazilian, and Japanese navy.



The Propeller Can be Rotated About a Vertical Axis to Function as a Rudder.



Launch Fitted With Motor-propeller Unit Exhibited at the Recent Paris Show.

Limits of Precision in Physical Measurement.—I. A. Harker in a review published in *Nature* remarks: As a sample physical measurement of the highest class under the best possible conditions may be considered the comparison of two similar platinium-iridium kilograms with all the refinements of a transposition balance, a "complete" set of weighings, and the utmost precautions. Under these conditions the thousandths of a milligram may be said to have some significance. Similarly in length measurements the difference in length between two similar standard meters of the highest class may be determined to a few hundredths of a micron, and the height of a meter column of mercury to a few thousandths of a millimeter. The last significant figure in the three cases is $1/10^9$, $1/10^8$, and $1/10^6$ of the whole respectively. These are the most favorable cases, but it seems unlikely that even with the best methods an interval of temperature can be measured with greater precision than about one part in a hundred thousand. Besides, if instead of the mass or length chosen in the examples here quoted an odd multiple of a fundamental standard be taken, the precision attainable may be only one-tenth of that given or even less.

Colloid Chemistry*

A Comparatively New But Exceedingly Promising Field

By John Waddell

Among the Greeks η κολλα denoted glue, and τα κολλωδη (whence the word *colloid*) were substances similar to glue. But to the Greeks, the phrase colloidal gold or colloidal silver would have sounded strange, nor did they dream of quartz in a colloidal form. And not to the Greeks alone were these terms unfamiliar—they were not used till comparatively lately; but of recent years great progress has been made in the study of colloids and now this branch of chemistry has attained remarkable prominence. Not only are there manuals on the subject, but journals are devoted to the recording of its development.

Nearly twenty-five years ago a great impetus was given to physical chemistry when Wilhelm Ostwald issued the first number of the *Zeitschrift für physikalische Chemie*, which has now reached its seventy-eighth volume. In 1906 Wolfgang Ostwald, a son of Wilhelm, issued the first number of the *Zeitschrift für die Chemie und Industrie der Kolloide*, and not only is it already in its ninth volume but, owing to the superabundance of the material provided, Beihefte are from time to time sent out.

As physical chemistry, with its theories of osmotic pressure, electrolytic dissociation, and the phase rule, has found application not only in industrial and analytical chemistry, but in a field whose breadth may be recognized from the fact that it takes in geology and metallurgy, on the one hand, and biology and physiology on the other; so colloid chemistry has in its domain the color of glass and precious stones, a matter which has been of interest from time immemorial, the coagulation of gelatine by tannin, long made use of in the leather manufacture, and the art of photography, a comparatively late by-product of scientific research.

Colloid chemistry may be considered a subdivision of physical chemistry just as electro-chemistry may be, but it is so large a subdivision that like electro-chemistry it takes a place of its own. Colloid chemistry may be said to have begun with Thomas Graham, who in 1861 published a paper in the Transactions of the Royal Society of London upon the separation of substances by diffusion. He found that some substances when dissolved in water and placed in a vessel of parchment paper floating in pure water pass readily through the parchment to the water outside. Sugar and salt and crystalline substances of that kind are among the number. On the other hand, albumen and gelatine and substances that do not crystallize, pass through parchment to a very slight extent. Graham divided soluble substances in this regard into two classes, crystalloids and colloids.

In 1870, Prof. John Tyndall delivered one of his brilliant lectures at the Royal Institution on "Dust and Disease." In the course of his investigations upon the subject it was necessary for him to obtain air perfectly free from dust particles. For this purpose he bubbled air through a solution of caustic potash and through strong sulphuric acid, expecting that these very powerful chemicals would destroy all of the dust, but to his surprise he found that this severe treatment was not effective. He found, however, that by passing air through a red-hot tube containing platinum gauze the dust could be burned and so removed.

How was the presence or absence of dust particles in the air detected? Just by making use of a phenomenon which we observe every time the sun shines into a room, and we watch the moles dancing in the sunbeam. By means of a converging lens an intense beam of light was made to pass through the air under examination. If dust was present it was made luminous and so visible, thus tracing out the course of the light; if dust was not present the path of the beam through the air was blank and could not be seen. This method Tyndall exhibited not only in the lecture mentioned but on many other occasions.

In 1903 Siedentopf and Zsigmondy constructed an apparatus depending upon the same principle by which particles far smaller than can be seen with the ordinary microscope may be made visible. It is an arrangement by which an intense illumination is obtained in the field of a powerful microscope. A very minute particle so illuminated disperses the light and is thus visible against a dark background. Particles of gold can thus be detected whose size is such that on the scale of magnification which would enlarge a red corpuscle of the blood to the diameter of 3 inches the gold particles would be only as large as the full stop at the end of this sentence. The apparatus by which particles of this size are made manifest is called an ultra microscope, and the title of Zsigmondy's book, "Colloids and the Ultra Microscope," indicates that there is a connection between the work of Graham and the work of Tyndall.

Let us again turn back to work done many years ago by Faraday. In 1857 he made experiments with gold chloride. Gold chloride in concentrated solution is yellow, but a sufficiently dilute solution is practically colorless. Chlorine and gold have not a very strong affinity and the chlorine can be removed in a number of ways and the gold obtained as a dark substance looking like a very fine black powder. If this black powder is collected and rubbed on a hard surface it can be made to show the ordinary color of gold. Faraday added to a very dilute solution of gold chloride a few drops of ether in which phosphorus was dissolved. It gave a ruby colored liquid without any metallic appearance and quite clear. Slight variations may be made in the experiment producing marked differences in the result. If calcium chloride is added to the gold chloride solution the addition of phosphorus in ether gives, instead of ruby, a violet or blue color. Addition of many different substances to the ruby solution change its shade in the same way. So also does boiling. The dark colored solutions give a sediment within a shorter or longer time seldom reaching as much as a week; the ruby-colored liquid may remain clear for years. In time, however, all of the liquids yield a dark sediment and the fluid above it becomes colorless. The ruby color is transparent, so also is frequently the violet, but before sedimentation takes place the liquid becomes cloudy. Faraday was of the opinion that the color in all cases was due to very fine particles floating in the liquid. It is well known that on account of interference of light, substances with no inherent color may acquire various tints, as is seen in mother of pearl where very fine markings produce the effect. Very fine particles produce a color in the same way. If the color is due to the presence of fine particles, those producing ruby would naturally be considered the smallest, for they remain longest in suspension. Faraday found that even the ruby liquid may present a slightly hazy appearance in an intense beam of sunlight, thus indicating the presence of very small particles.

Within recent years not only gold but nearly all other metals have been made to color water or some appropriate liquid, producing what appears to be a solution. For this purpose, an electric arc is formed or electric sparks passed between wires of the metal placed in the liquid. The metal is volatilized, part of it collects and forms a sediment and part remains in the liquid producing a color. In no case does the color thus produced equal in beauty the brilliant ruby shade produced in Faraday's experiment with gold.

It does not appear that Graham, when working with colloidal solutions a few years after Faraday's experiments with gold, considered that there was any connection between the two. His theory of colloid solutions was that they were like crystalloid solutions except that the colloid material dissolved consisted of large molecules, too large to readily pass through parchment paper. For thirty years, work more or less desultory was carried on; a number of colloid solutions were prepared, ferric hydroxide, a modification of iron rust, and aluminium hydroxide closely akin to corundum, were obtained in soluble form. But though new preparations were made, very little attention was paid to theoretical considerations. It was found that while sugar, salt, and similar substances in solution exert osmotic pressure and lower the freezing point of water, colloids had but little effect. It is commonly known that the water of the ocean requires a lower temperature to freeze it than does the fresh water of rivers and lakes, and crystalloid substances have to a greater or less extent the same effect as sea salt. Other things being equal, the greater the molecular weights of the crystalloid the less the effect of a given amount of it. Hence if colloid substances have a molecular weight very large as compared with crystalloid, the very small effect in lowering the freezing point would be explained.

Sulphide of arsenic and some other sulphides were obtainable in a colloidal state and when Carey Lea, in 1888, produced a water soluble substance containing over ninety-five per cent of silver, it was called colloidal silver and was considered to be an allotropic modification of the metal. In 1891 Barus and Schneider carried out investigations which in their view indicated that colloidal silver was not an allotropic form, but that it was ordinary silver in a very fine state of division. Set over against each other were then the two theories, the solution theory and the suspension theory. Most investigators had adopted the former, though Berzelius, Richter, and Faraday before the term colloid had come into use, had dealt with liquids of that class and had attributed the phenomenon to finely divided particles. However, the contest went on until in 1903 the ultra-microscope of Siedentopf and Zsigmondy made visible, in many colloid solutions, distinct particles and thus obtained a triumph for the suspension theory or, as it is sometimes called, the theory of heterogeneity.

As geologists distinguish, according to the size of the particles, between pebbles, gravel and sand, so Zsigmondy distinguishes in a similar manner between suspensions and colloidal solutions. Suspensions may roughly be taken to include particles of all sizes from microscopic up, which will float in the liquid; colloidal solutions include all particles of smaller size. The boundary between the two is about 1/10,000 of a millimeter (1/250,000 of an inch), the limit of visibility with a microscope. With the ultramicroscope particles of 1/20 this size may be detected and colloidal solutions contain not only these particles but some so small that we are not able to detect them in any way.

It is not possible by simple grinding to make any insoluble substance so fine that it will act like colloidal solution; it would merely form a suspension. But by the action of chemicals upon each other particles so fine may be produced that a colloidal substance will appear. The more insoluble the substance produced, the more likely is it that such a substance will be formed. Every analytical chemist meets a phenomenon like this frequently. When barium chloride is added to a soluble sulphate a very insoluble substance is produced and some of the particles are so small that they are liable to run through the filter. If both solutions are very dilute no precipitate may be formed for some seconds. Probably during part of that time, at least, the greater portion of the barium sulphate may be in a colloidal state, and some of it may continue in that form. At all events, the addition of electrolytes such as hydrochloric acid or ammonium chloride assists in the coagulation of the barium sulphate just as electrolytes cause the coagulation of colloidal gold. So also nitric acid is added to aid the precipitation of silver chloride. Less insoluble substances form larger crystals which are not liable to run through the filter.

Hydrosols, as colloidal solutions in water are called, when evaporated change to a jelly or solid residue. In some cases this residue can again be dissolved by addition of water. This is the case with glue, gum arabic and similar substances. They are *reversible* hydrosols. *Irreversible* hydrosols, like colloidal metals after precipitation, and completely dried silica, cannot be redissolved. Reversible hydrosols are not usually affected by electrolytes; irreversible hydrosols are for the most part extremely sensitive, tending to coagulate. A solution of a reversible hydrosol added to an irreversible one tends to make the latter reversible. Thus a colloidal solution of gold mixed with glue when dried up has a blue color, but addition of water brings it back to its original condition. The reversible colloid acts as a protection to the irreversible.

Colloidal solutions are poor conductors of electricity, but if two electrodes differing by 120 volts or more are placed in the liquid, the colloid will collect mainly at one or other of the poles. This seems to indicate an electric charge upon the particles, though it may be due to the presence of a very small quantity of an electrolyte. In any case, where the particles seem to be negative since they collect round the positive pole, they appear to be more readily coagulated by the positive ions and conversely positive particles are coagulated by negative ions.

One of the most notable hydrosols is that of gold already mentioned, an irreversible hydrosol, not forming a jelly like silicic acid, but a more compact material which settles into a small bulk under the influence of the proper electrolytes. In the ruby-colored hydrosol no doubt some of the particles are too small to be detected even with the aid of the ultra microscope, whose limit is reached when the particle is so minute that, using the standard already employed, fifty or sixty thousand of them could lie side by side on the diameter of the following full stop. The average particles are a little larger than this; twenty or thirty thousand only could lie together across the dot, their diameter being fifteen millionths of a millimeter. The number of them required to make a weight of one gramme, or fifteen grains, is approximately represented by the figure one followed by sixteen naughts. It is only when these particles join to form larger ones that they settle, and the particles thus produced have about twenty times the diameter of the smallest that can be detected by the ultramicroscope, and are almost if not quite visible with a powerful microscope of the ordinary kind.

Zsigmondy discovered that the finest particles have a very remarkable motion. It has been long known that microscopic particles like the globules of fat in milk have a more or less vibrating motion, the so-called

* Republished from *Queen's Quarterly*.

Brownian motion, but the motion of the gold particles is of a very different order. Zsigmondy, who describes these motions in his book on colloids, was so surprised when first he saw them that for some time he hesitated to publish his discovery. He expected that the gold particles in colloid solutions would be as quiet as those in real suspensions. After making this statement he adds:

"How entirely erroneous was this idea! The small gold particles no longer float, they move—and that with astonishing rapidity. A swarm of dancing gnats in a sunbeam will give one an idea of the motion of the gold particles in the hydrosol of gold. They hop, dance, jump, dash together, and fly away from each other, so that it is difficult in the whirl to get one's bearings. The motion gives an indication of the continuous mixing up of the fluid, and it lasts hours, weeks, months, and, if the fluid is stable, even years. Sluggish and slow in comparison is the analogous Brownian movement of the larger gold particles in the fluid, which are the transition forms to ordinary gold that settles. The smallest particles which can be seen in the hydrosol of gold show a combined motion, consisting of a motion of translation, by which the particle moves from one hundred to one thousand times its own diameter in 1/6 to 1/8 of a second, and a motion of oscillation of a considerably shorter period, because of which the possibility of the presence of a motion of oscillation of a higher frequency and smaller amplitude could not be determined but is probable."

Allied to the ruby-colored colloidal solution of gold is ruby glass. It is made by adding chloride of gold in small quantity to molten glass. The molten glass does not become colored. When quickly cooled it remains colorless and even when slowly cooled no color may appear. The ruby color is nearly always brought out by heating the colorless glass to the softening point, which is several hundred degrees below the temperature at which the glass is made. Poorly made or spoiled ruby glass, as it is called, has a blue or violet shade.

The process of coloring can be illustrated by heating a strip of colorless ruby glass at one end while the other is kept cold. At the spot where the heating takes place the red color develops and grows fainter toward the cold end where no change takes place. Where the red color is fully developed particles may be detected by means of the ultramicroscope; where it is faint particles are no longer visible but probably exist, though very minute. In the colorless portion there are probably few if any particles, the gold being in the form of a compound in the glass and not in the metallic condition, or, if metallic, dissolved in the same way that sugar is dissolved in water. Spoiled ruby glass acts in a somewhat similar manner to good ruby glass, but the particles are much brighter and larger, are much farther apart, and can be detected farther from the heated end.

The formation of gold particles in softening glass is in many respects similar to the growth of crystals. In a solution, crystals grow round nuclei. If a supersaturated solution is cooled far below its supersaturation point crystallization does not take place even though nuclei are present. The case of the glass is similar. When the glass is cooled, nuclei are formed, but the gold in solution does not deposit on these nuclei. There is no freedom of motion of the molecules of gold in the hard glass. When, however, the glass is heated to the softening point the molecules move more freely, the nuclei grow and the particles become sufficiently large to give a ruby color. Under ordinary circumstances only about half of the gold separates out; the balance remains in homogeneous solution. When the glass is heated to a very high temperature the solubility of the gold increases, the particles disappear, and the glass again becomes colorless.

A very important recent application of colloid chemistry is in the preparation of filaments of tungsten for electric incandescent lamps. In the construction of a lamp the object aimed at is light efficiency, the production of as great illuminating power as possible for a given expenditure of electric energy or, conversely, the use of as little energy as possible for a given illumination. It is readily seen that the higher the temperature of the filament the greater the efficiency.The light obtained from a filament heated till it becomes just faintly red is practically useless, but to produce it very considerable energy is required and much less than double the energy would increase the illuminating power more than twenty-fold.

The metal tungsten is very infusible and can be heated to about 2,800 deg. Cent. without melting or deteriorating to any considerable extent, whereas carbon filaments, which have been used almost universally until very lately, should not be heated beyond a temperature of 1,800 deg. Cent. The extra thousand degrees of temperature makes a very great difference in the luminosity. To attain the high temperature it is necessary that the filament should be made very thin; a diameter of 0.03 mm. is suitable. Nine hundred of these threads could lie side by side in an inch, five of them together have approximately the diameter of No. 40 cotton thread. It is easy to draw out gold and silver wire to this degree of thinness, but tungsten is a very brittle metal which could be obtained only in the form of a powder until the high temperature got by use of electricity made it possible to melt the powder into a compact mass which, however, as just stated, cannot be drawn out into wire. But when the metal is changed into the colloidal state it becomes plastic and can be forced by pressure through a very fine hole, thus producing a thread.

Grinding the metallic powder for months does not serve to produce the fine state of division of a colloid, but the very fine powder after being treated alternately with alkalies and acids becomes colloidal and when precipitated is of such consistence that if pressed through minute holes bored through ruby, threads of the required thickness may be obtained. Wire prepared in this way has little coherence, but when a suitable electric current is passed through it the fine particles unite at the higher temperature produced to form a solid metal thread of good electric conductivity.

The application of colloid chemistry to dyeing depends upon the phenomenon called *adsorption*. Many substances have the power to condense gases upon their surface and to hold firmly, liquids and finely divided solids. Glass, for instance, is covered with a very thin invisible but often not negligible coating of water and gas which can be got rid of only by heating for some hours in a vacuum. The adsorptive power increases with the surface and depends upon the nature of the adsorbing and of the adsorbed substance. Certain colloids are especially readily adsorbed by certain other colloids. Hence filters in which the pores are far wider than the diameter of the particles in a colloid solution can often be used for separating the colloid from the liquid. Were it not for this adsorptive power of colloids the obtaining of a clear liquid by filtration would often be impossible, and so the chemist in the laboratory as well as the municipal engineer sometimes depends for the success of his operations upon this phenomenon. On the other hand, adsorption makes it more difficult than it otherwise would be, to wash precipitates obtained in the course of analysis from the surrounding liquid, and so acts as a hindrance. This is particularly the case when the solid forming the precipitate is a colloidal jelly, as when ferric hydroxide is precipitated by a solution of caustic potash. It is almost impossible to wash out the potash.

Colloids have a selective power of adsorption. Some colloids are not only not adsorbed by certain others, but act as a protection to colloids which otherwise would be adsorbed. Filters which prevent colloidal gold from passing through them under ordinary circumstances, cannot keep back the particles if the liquid contains some egg albumen as well.

In a number of dyes the ultramicroscope shows the solution to be colloidal, and even where the particles are too small to be individually detected the colloid character is frequently observable. While the theory of dyeing is not complete, it appears that in many cases the material of the fabric acts as a colloidal jelly which adsorbs the colloidal dye stuff as ferric hydroxide adsorbs potash. Sometimes the fabric itself does not adsorb the dye stuff but can take up a colloidal *mordant* which is capable of adsorbing the dye. When cotton is soaked in alum solution and then treated with soda, aluminium hydroxide is formed as a colloidal jelly which permeates the material and can adsorb many of the colloidal dyes and thus the dyeing is effected. It is not the object of this review to go into details; it is evident that a large domain is here opened up.

Nature works on a large scale as well as on a small. In streams, lakes, and rivers processes go on by which from hard and massive rocks colloidal solutions are made. When these reach the sea the salts present coagulate the fine particles which settle to form a sediment. This sediment makes an exceedingly fertile soil and may be used to enrich poorer land. Here is one point out of several in which colloid chemistry touches upon agriculture.

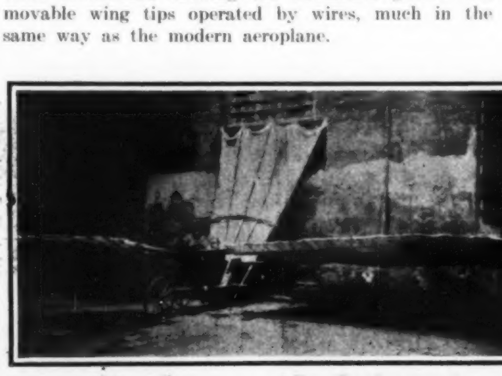
The Early History of Wing Warping Devices

Who Is the True Inventor?

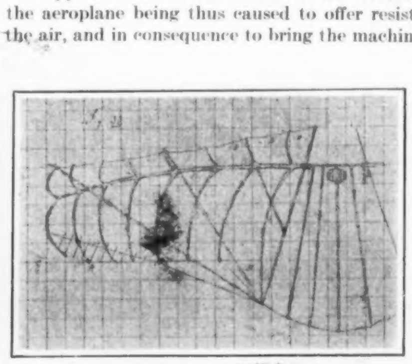
In the long extended discussions which have centered around the question of proprietary rights claimed by the Wright Brothers for the use of warping devices for aeroplane wings, and more particularly for the use of these in combination with a vertical rudder, probably the most interesting quotation from the prior art which has been brought to light is that from the work of a Frenchman, Louis Mouillard, a resident of Cairo, where his work was performed and his manuscript book written.

The French paper, *L'Illustration*, once more brings up this subject and gives us some very interesting quotations from Mouillard's work, which it may be mentioned incidentally has been purchased in the name of the French National Aerial League, by Mr. Antoine Bianchi. The book is entitled "Le Vol sans Battement," and has been unearthed thirteen years after the death of its author, from the vaults of the French Consulate of Cairo.

L'Illustration takes a patriotic stand in the situation and claims for the French practically the entire glory of the invention of all the essentials of aviation. Whether we follow them entirely in this must depend to some extent on the construction which we lay upon the passages from Mouillard's book that are quoted by A. Henry-Courannier, who writes in *L'Illustration* and to whose charge it has fallen to examine the papers found at Cairo. The writer goes so far as to claim for Mouillard the invention not only of warping but that of the combination of wing warping with the vertical rudder. So far as the warping is concerned, there can be absolutely no question that Mouillard very clearly described and figured the device to effect this. We reproduce here an illustration from an earlier issue of the Scientific American, showing the Mouillard glider with movable wing tips operated by wires, much in the same way as the modern aeroplane.



Mouillard Glider of 1895, With Movable Wing-tips.



Bamboo Skeleton of Wing.

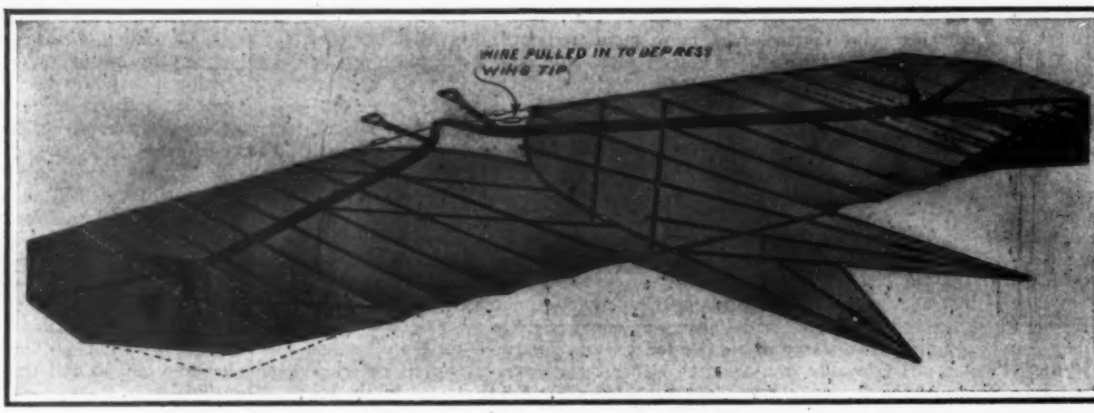
In support of the contention that Mouillard even anticipated the Wrights in the matter of the combination of warping with vertical rudder, Henry-Courannier quotes the following passage from Mouillard's writings:

"When the aeroplane in its flight attempted to follow some other direction than that of a head wind, this stiff plane* followed the air current. . . . . This deviation immediately produced a traction upon a cable such as to oppose this new direction of the vertical rudder, the aeroplane being thus caused to offer resistance to the air, and in consequence to bring the machine again into the wind." But the matter does not end here. Not only is Mouillard thus shown to be the inventor of warping in combination with vertical rudder, but it is established beyond question that Chanute not only read Mouillard's book but applied for a patent in the name of Mouillard on September 24th, 1892. This patent was issued on May 18th, 1897, and bears

* A vertical rudder, according to *L'Illustration*.

No. 582,757. It clearly describes the feature of wing warping.

Its text was edited by Chanute, Mouillard himself not being familiar with patent matters. Chanute



The Mouillard Glider Had Movable Wing-tips, Operated by Wires, as on a Modern Aeroplane.

Louis Mouillard.

was so convinced of the efficacy of the new means proposed by Mouillard that he sent to the French inventor a check for $2,000 for the construction of an aeroplane according to the plans of the patent. The work of Mouillard, says *L'Illustration*, was communicated to the Wright Brothers by Chanute. In fact, the Wright Brothers themselves clearly acknowledge their indebtedness to Mouillard in an article which appeared in the *Century* magazine, from which the following quotation may be made:

"Mouillard and Lilienthal, the great prophets of aviation, have communicated to us their untiring enthusiasm and transformed our placid curiosity into the active exertions of the usually creative inventor."

Whatever may be the final conclusion with reference to the situation, there can be no question that the Mouillard manuscript forms one of the most interesting historical documents brought to light in connection with this important patent suit, or indeed in any dispute of this kind on record.

Compact Hydrogen Generators

The Silicon-Caustic-Soda Process for Field Use

Portable plants for the preparation of hydrogen have acquired considerable interest and importance of late in connection with the extensive development of aeronautics. In military work, particularly, it is essential to have at one's disposal some compact and readily transportable plant for generating the gas for balloons. Various processes have been proposed and tried for this purpose. One of these, which in practice has proved very satisfactory, is the silicon sodium hydroxide process, portable plants for which are put on the market by the Elektrizitäts-Aktiengesellschaft of Nürnberg.

The reaction takes place without external application of heat, simply by the aid of the heat liberated in the reaction itself. For the production of one cubic meter of hydrogen there are required one kilogram of silicon and 1.2 kilograms of caustic soda.

The apparatus employed is made in portable form, as shown in our accompanying illustration. A small gasoline motor is used for drawing the requisite water supply from any convenient source. This motor, with the pump, is mounted upon a common base which in turn travels on wheels. In case it should be impossible to wheel the motor right up to the source of water, it can be lifted off the truck and carried to a suitable point. With this in view, some 65 feet of extra portable tubing are furnished with the apparatus.

Such portable plants are now made for the production of 60 and 120 cubic meters of gas per hour. In the 60 cubic meter type, the entire plant is mounted upon one truck and has a maximum weight of about 2,500 kilograms, or 5,510 pounds. A separate truck must be provided for carrying the raw materials. This truck is not sold with the apparatus. The plant consists of a charger, a generator, and a dissolving tank. In addition to these there is a scrubber and the small gasoline pump mentioned. The 120 cubic meter plant is mounted on two trucks, of which one carries the charger, generator and dissolving tank, and the other the scrubber with the gasoline motor. The maximum weight of these trucks is 4,620 and 5,060 pounds respectively. Stationary plants to the capacity of 1,000 cubic meters of hydrogen are also built by this firm. The pump is similar to that of the portable plants, but as a rule the pump is not furnished with the plant.

In order to avoid the necessity of weighing out the materials for use in the portable plants, it is desirable to carry the silicon and caustic soda in hermetically closed tins containing each 24 kilograms of silicon and 18 kilograms of soda respectively. In this case, 1 tin of silicon and 2 tins of caustic soda are required to produce 30 cubic meters of hydrogen.

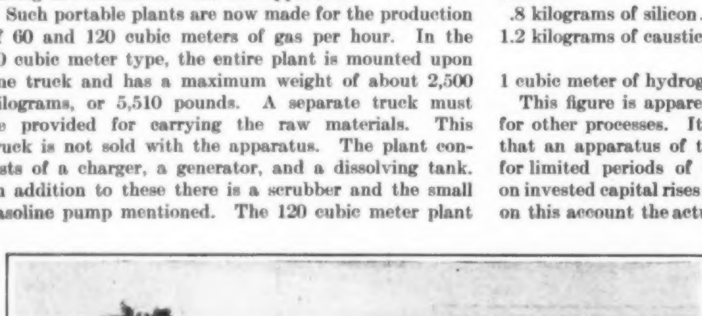
A number of advantages are claimed by the makers for this system, such as low first cost of the plant and compactness and small weight of the apparatus and raw materials, which render the plant particularly adapted for field use. The operation of the plant is exceedingly simple and the apparatus is ready for use at any instant. It is said to be very durable in construction and furnishes a very pure gas, free from arsenic.

The cost of the raw materials, according to German conditions and when bought in quantity, is about as follows:

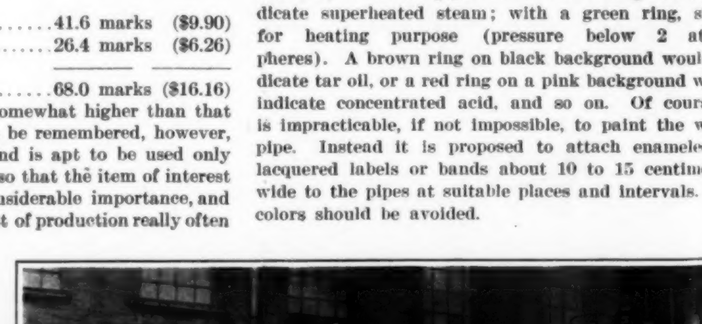
.8 kilograms of silicon	41.6 marks	($9.90)
1.2 kilograms of caustic soda	26.4 marks	($6.26)
1 cubic meter of hydrogen	68.0 marks	($16.16)

This figure is apparently somewhat higher than that for other processes. It must be remembered, however, that an apparatus of this kind is apt to be used only for limited periods of time, so that the item of interest on invested capital rises to considerable importance, and on this account the actual cost of production really often turns out to be less by this process than by other processes.

Standard Colors for Pipe Systems.—The uncertainty of the contents of pipes in industrial plants, mines, etc., especially in cases of emergencies, is a well-known danger. German engineers have therefore decided on standard colors for pipe systems, and according to *Zeitschrift des Vereins Deutscher Ingenieure*, have agreed upon the following colors: Green is to indicate drinking water (for pressure not exceeding 5 atmospheres); yellow, waste gases; blue, air; white, steam (under pressure); black, tar; pink, lye; brown, oils; and gray, vacuum. A red ring or band indicates danger; a black ring, impurities. These colors and rings permit of various combinations. Thus a green pipe with a black band would indicate sewage or waste water; with a red band, water under pressure; with a pink band, salt water (such as used in cold storage plants, etc.); with a white band, warm water; or a yellow background with a blue ring would indicate producer gas; with a green ring, water gas, or with a brown ring, oil gas. A blue pipe with a red ring would carry air under pressure; with a white ring, hot air; a white pipe with a red ring would indicate superheated steam; with a green ring, steam for heating purpose (pressure below 2 atmospheres). A brown ring on black background would indicate tar oil, or a red ring on a pink background would indicate concentrated acid, and so on. Of course it is impracticable, if not impossible, to paint the whole pipe. Instead it is proposed to attach enameled or lacquered labels or bands about 10 to 15 centimeters wide to the pipes at suitable places and intervals. Oil colors should be avoided.



Portable Plant. Hourly Capacity 120 Cubic Meters.



Stationary Plant of 300 Cubic Meters Hourly Capacity.

Net for Vertical Fishing.

A Floating Zoological Experiment Station

Studying the Fauna and Flora of Lakes

By Our Berlin Correspondent

Handling the Drag Net.

While the great inland lakes of Maine, of Sweden, of Finland and other countries, covering as they do from seven to eleven per cent of the total area of their respective States, are not of the same international importance as the great ocean sheets, they nevertheless possess a very considerable economical and scientific interest.

Of late years the study of lacustrine flora and fauna has been carried on with much energy, special institutes have been devoted to the subject in various countries, and great strides have been made in the advancement of this brand of science. Such points as the configuration of the lake bottom, variations in level, the movements of the body of water, temperature observations, etc., have received special attention.

In view of the surprising results obtained in the field of the submarine fauna and flora of the ocean, it was thought interesting to extend the same type of researches to inland lakes. This new addition to scientific investigation has been cultivated with especial care at the University of Geneva (Switzerland), where the wonderful Lac Léman has been the theater of many classical experiments.

Madame R. H. Claparède, the daughter of the celebrated zoologist, conceived the plan of endowing the University of Geneva with a small research vessel, comparable with those used for submarine investigation. Last year, in conjunction with some other donors, she therefore endowed Prof. Yung's laboratory with the means of purchasing a motor boat to be fitted up as a floating lake-zoology station.

The "Edouard Claparède," as the boat is called, is of course of far more modest dimensions than the "Princesse Alice" belonging to the Prince of Monaco, and other submarine research vessels, in accordance with the smaller area covered by the Lake of Geneva. Though a fresh-water boat, it is of substantial and solid construction and will doubtless prove a most useful means of promoting and facilitating lake study. It is 40 feet in length and is driven by a 14 horse-power motor, at a speed of 8⅔ miles per hour. It is equipped with a small zoological laboratory, comprising a collection of nets, sounding devices, drags, etc. A capstan on which a steel cable 1,650 feet long is wound and a rotary crane, greatly facilitate the hauling of the fishing outfit.

The present program of this floating zoological station is to add as far as possible to our knowledge of the lake fauna. It has already been shown that though this fauna only comprises a relatively limited number of species, the number of individuals of each species is enormous, and as Prof. Yung's personal research work is more concerned with general biology and physiology than with systematic biology, the problems primarily to be elucidated are those relating to the periodical migrations of lake organisms, their alimentation, their behavior towards variations in the chemical composition of the water, etc.

Nickel Steel for Electroplating and Electrotype Work

A Hard, Highly Resistant and Non-corrosive Alloy

The use of special steels has become so widespread in the most varied branches of industry, that one is hardly surprised to hear of further extensions in the application of these alloys.

A company having its headquarters in New York city is making a specialty of exploiting several processes, in which the electrolytic deposition of special nickel iron alloy is turned to useful account in a number of different ways. One of these is a special electrotype process, designed to replace the usual copper process, over which it has a very marked advantage in that the plates produced are much more lasting and can, therefore, give a far greater number of impressions than can be obtained with an ordinary copper electrotype plate. The grain of the metal is also finer, and a finer meshed screen can, therefore, be employed than with a copper plate. The electrotype may be obtained in the form of a thin, elastic, and very strong and tough sheet, which readily adapts itself to use on printing rolls or any other curved surface. If desired, it may of course be backed in the usual way with any suitable backing metal, either the one customarily employed, or one harder and more resistant. A backing of the latter kind will be employed particularly where the plate is to be used for high pressure hot press work, as in printing gilt decorative covers for books, etc. It is to be noted that the copper electrotype process is hardly available for this purpose, as copper is too soft, and it is customary to prepare dies for back covers and the like, by cutting them from brass or bronze plates. The use of the new ferro-nickel alloy, therefore, makes possible the preparation of such plates by electro-deposition, thus saving much work and expense in the cutting of plates. Not only is the nickel-steel electroplate very hard and fine-grained, but it is non-corrosive and highly resistant to every kind of ink that enters into use for printing purposes. This is not the case with ordinary copper plates, and thus a very material advantage is gained.

The mode of procedure in preparing the plates is, in general, similar to that followed in the case of copper electrotypes. Thus, for example, if some photograph or sketch is to be reproduced, the first step is to prepare a zinc etching or, in some cases, a copper etching, which then functions as a molding pattern, from which a wax mold is prepared. This mold is black-leaded and a layer of alloy is deposited thereon, to a depth ranging 2/1,000 to 35/1,000 inch. Incidentally, it may be mentioned that the usual "after metalling" of the black leaded mold is omitted in this process.

A special purpose for which the new electro depositing process is applied with the greatest advantage is the preparation of phonograph records. Ordinarily, a copper matrix is prepared from the original record by electro-deposition, and such matrix can then be used to prepare, at the outside, some four hundred copies. The advantage gained by the use of the new nickel-steel alloy in place of copper in this process is readily understood when we are told that from a plate thus prepared no less than 11,000 to 12,000 copies can be prepared from one matrix.

Another of the processes controlled by the same company is an electroplating process for all kinds of metalware, such as table and kitchen utensils, etc. The plating is highly resistant to all kinds of agents such as are apt to come in contact with spoons, forks, etc., and the statement is made that at one of our large hotels, it has been found that a very material saving in the daily expenses for cleaning tableware is secured by the use of the new electroplate, owing to the fact that it is very much less liable to staining than materials commonly employed, and especially silver. In connection with the plating of various utensils for general use, it is interesting to note that the new process can also be applied for electroplating aluminium, an operation which has hitherto presented a great deal of difficulty.

The field of applicability of the electroplating process is extremely varied and extensive as a non-corrosive and very flexible coating can by this means be applied, not only to metal but to such substances as leather, rubber, celluloid, wood and all sorts of plastic materials.

The same company which owns the patents for the use of nickel-steel electrotyping and electroplating work also owns a peculiar and very interesting process, by means of which copies of all sorts of plastic objects can be prepared on an altered scale, either enlarged or reduced. The process consists in the use of a peculiar molding material, which admits of being squeezed into small compass or drawn out into larger size after the impression has been made therein. Reproductions thus obtained are perfect copies on an altered scale of the original. The value of this process will be readily understood when we consider that in many instances the production of a first mold, especially in the case of art work, is an exceedingly costly operation, and in case the same design is needed on a different scale, the entire process of preparing the mold must ordinarily be gone through a second time. Thus, for instance, a set of tableware may have a certain design occurring in different sizes on different pieces of the set. The new process makes it possible to prepare the first mold by any operation desired, and thereafter the remaining molds, on an altered scale, can be prepared entirely by mechanical means.

Apart from the obvious advantages of this process, a further point is gained in that, the material of the mold, being elastic, undercut parts can simply be pulled out of the mold, and the corresponding portions of the mold spring back into place after the undercut parts have been withdrawn from their seat. It is claimed that by the new process two or three men are able to do the work of thirty performing the operations by the usual hand-work methods.

Still another process practiced by the same company is the production of relief medallions from paintings, engravings, sketches, photographs, etc., by a direct mechanical process. The course of operations is somewhat as follows: The original is copied photographically and considerably enlarged. It is then gone over with special pencils to reinforce the high lights, etc., and a copy on the original scale is then prepared on sensitized gelatine. By a special process of treatment of the gelatine after exposure, it is caused to swell in the portions affected by the light, with the result that a plastic reproduction in relief of the original is obtained. Copies may then be prepared from this in any suitable manner, by electro-deposition or any other method of molding.

The processes controlled by this company present not one but many very interesting features, and further developments will be watched with much interest.

Unbreakable Glass.—By the addition of a large quantity of the oxides of manganese and zinc to ordinary lead glass, the elasticity of the glass is much increased. This glass is used in France for the manufacture of miners' lamps. According to a statement of Mining Engineer Ch. Chesneau, this glass can be heated to 100 deg. Cent. and then suddenly cooled off by water of 15 deg. Cent. without breaking. The following is the composition of the glass: 75 parts of sand, 13 sodium bicarbonate, 9 magnesium carbonate, 6 zinc oxide, 50 red lead. A glass which is still more indifferent toward temperature changes is made in Germany (Bara-silicate glass), and used for steam gage tubes and the like. Such a glass tube, 2.5 millimeters thick, can stand a pressure of 300 atmospheres, and can safely be chilled from a temperature of 230 degrees by throwing cold water on it.—*Chem. tech. Rep.*

Deep Ploughing With Dynamite

Modern Methods in the Most Ancient of all Industries

Leading agricultural authorities everywhere are advocating deep tillage both as a means of increasing crops and as protection against such disastrous dry spells as characterized the summer of 1911. There seems to be no difference of opinion as to the advantages of deep tillage, but there is in regard to the method of doing the work. What might be called the natural method is the planting of crops such as alfalfa, whose large and powerful tap roots will penetrate a rather compact subsoil to a depth of 6 feet or more and in a few years render it more or less open and give it a sufficient content of humus to materially increase its fertility and water-ho'ding capacity.

A more rapid method of deep tillage is with the subsoil plough which breaks up the soil to a depth of 15 to 20 inches. This, however, is rather expensive and very hard on men and horses.

Within recent years a third method of subsoiling has been the subject of extensive experiments, namely, with dynamite. The results of these experiments, when the same were conducted under proper conditions, have been quite remarkable. Cotton yields have been doubled, tripled and quadrupled by subsoiling with dynamite. Corn has responded splendidly to this treatment. Cereals, hay, fruit trees, tomatoes, beans, watermelons and various other crops have all shown substantially increased yields when the subsoiling has been done in dry weather, preceding the rainy season. In the North the best time for subsoiling has proved to be from May to November for showing results the next year, and in the South from October to February 1st.

The publicity given to these astonishing results which point to a revolution in farming methods, has naturally created much inquiry in the minds of the farmers as to the cost of subsoiling and the length of time before subsoiled land will have to be again subsoiled in order to keep it open. This question is obviously difficult to answer, because of the lack of long time results, as, with the exception of a few pioneer users of dynamite, most of the remarkable results noted have occurred within the last year or two. Fortunately, however, there were enough of the pioneer users to prove that the effects of subsoiling lasts for many years. The cost averages about $15.00 an acre, including dynamite, caps, fuse and the labor of making the holes and doing the blasting. In most cases the cost is recovered within the year, out of the increased yield, but in other cases where the increased yield would not be worth more than $15.00 an acre, it is important to know how long this increased production is going to keep up so as to justify the expense.

Let us first consider the matter from a theoretical point of view. The reason why deep tillage or subsoil plowing is desirable is that all the soil below the bottom of the ordinary plow cut, in other words everything below 6 to 8 inches, is still in its primeval condition. It has never been disturbed. Chemical analyses of soils down to a depth of 20 feet show that on the average acre there are tons of plant foods which become available only when roots can penetrate to them, or when ascending moisture brings them up to the roots that can not get down. Alfalfa and other deep rooted plants are called "soil makers" because they penetrate this compact soil, introduce humus and provide a passageway for the descent and ascent of water which carries with it the soluble, fertilizing elements, but many subsoils are so hard that it is practically impossible for any one plant to penetrate them. Even when this is possible there is no use in putting such a burden on the plant, because whatever vitality is expended in making its own home beneath the surface, is subtracted from the vitality of the plant above the surface. In other words, the plant that has to fight for its life beneath the soil, has little energy left for fruition.

If we make root growth easy and quick by breaking up the subsoil, then we make the fertilizing elements of the subsoil immediately available and save the energy of the plant for fruition. We also create in the subsoil a porous condition favorable to the storage of water at a depth that will not keep the soil cold, and yet near enough to the roots to feed them through capillary action. Subsoiling also introduces air into the soil, and it is just as necessary for the roots of a plant to have air as it is for a human being to have air.

Now it is obvious that the passage of air and moisture through the soil, the growth of roots and the resulting deposit of humus, all tend to keep the soil open, hence, if it is once thoroughly shattered with dynamite to a depth of five or six feet and the principles of crop rotation are followed thereafter, it is safe to say that that subsoil will never again get back into its primeval compact condition. Whether or not it remains as open as immediately after blasting, depends on the continuity of cropping and the proper rotation of the crops.

The effect of subsoiling virtually is to change a farm from a six-inch layer of top soil to a six-foot layer. The only element of fertility lacking in the lower 5½ feet is humus and that will be found in the subsoil in ample quantity after the first year's cultivation. The significance of this conclusion must be appreciated by any careful agriculturist, because it means a tremendous increase in available fertility and a practical means of insurance against droughts. It does not constitute a substitute for ordinary plowing. Cultivation of the top soil is always necessary whether the subsoil is broken or not, in order to prevent the growth of weeds, loss of moisture from evaporation and the formation of a waterproof crust.

So much for the theory. Now let us turn to practical results for a demonstration of the value of the theory. One of the first uses of dynamite for subsoiling was in tree planting. Twenty-one years ago W. R. Gunnis planted an orchard with dynamite at La Mesa, Calif. This orchard matured more rapidly than orchards set out with a spade, resisting drought and other unfavorable conditions with marked success, and although the tract has been subdivided and used as a residence property, some of the trees are still thriving and for years this orchard was recognized as the most productive in the neighborhood.

W. W. Stevens, Orchardist, Mayfield, Ga., planted trees with dynamite eighteen or twenty years ago. He says:

"They are the finest trees I have ever seen grow for their age. In the planting of peach trees I gained two years in six; in other words, I got as much fruit from a tree planted with dynamite at four years old as we usually get at six years old. I not only plant them with it, but where a tree is failing and seems to be on the decline, I start it off to growing again by firing charges from three to ten feet apart. Nothing seems to tickle the earth so much as planting watermelons after explosion of dynamite from three to four feet under ground."

Mr. James Craig, president of the Rose Cliff Fruit Farm, Waynesboro, Va., began planting trees with dynamite nine years ago. He writes under date November 15th, 1911:

"I should think from the thoroughness of the work done by dynamite that it will last fifteen or twenty years without question."

Mr. Craig plants all his trees with dynamite.

Mr. Arthur E. Cole, proprietor of High Point Farm, a small-fruit nursery at Chamblee, Ga., writes as follows under date of November 17th, 1911:

"About eight years ago the New Roswell Road was graded. In the cut through the steep hill just south of Nancy Creek, between the eight and nine mile post (from Atlanta), much blasting was done. A vigorous growth of clover and young sycamore trees immediately sprang up on the roadside where this blasting was done. The clover seed found their own way from the hay where the mules were fed, into the porous soil where the dynamite was used. A good stand has appeared each succeeding year without any cultivation. Noticing this, I began to observe rock quarries and other places where explosives had been used, and found similar conditions prevailing. Wherever the ground has been broken with dynamite a perfect system of subsoiling results. Cut a cake of butter with a sharp knife; the cut surface is left hard and smooth. Just so in subsoiling with a plow. It rains, the water soaks through topsoil and then follows the course of the plow, soaking no further. But in subsoiling with dynamite, exactly the opposite condition prevails. The ground is 'heaved,' shaken and broken many feet deep, and is left so open and porous that all the rainfall is absorbed and retained. This is given back as growing crops demand. Subsoiling with 25 per cent low freezing dynamite has now become a common practice with farmers and orchardists. This process has the double advantage of *irrigating* and *draining both at one time*. Each place where a cartridge is discharged becomes an underground reservoir, and if thus broken in squares of ten to fourteen feet, with one-third to one-half stick of 25 per cent dynamite, the ground will be sufficiently broken for drainage from hole to hole as a result. Perhaps the most valuable feature of subsoiling with dynamite is the lasting effects. Modern machinery can plow our ground very fast but the work is not permanent, while in dynamited land the good effects are *underneath* and not affected by sun or wind and the porous condition *remains for years*. Of course the length of time varies with different soils and different crops and different modes of cultivation—limestone soil remaining open longest. Once the land is well subsoiled with dynamite and leguminous crops, peas, alfalfa, clover or rye are sown, thus feeding nitrogen deep into the soil from the air through the roots, a porous subsoil may be expected for from 3 to 4 years from one dynamiting. Of course it is not necessary to keep these particular crops growing continuously, but a good idea is to rotate, using one of them every second or third year. Last spring I dynamited some tree holes on my place, spaced about 25 feet. About mid-summer when everything was dry as a crisp from severe drought, I decided to plant vegetables in the same rows with the young trees, between these dynamited holes. It was a test case and no cultivation was given, except one hoeing. The results were wonderful. I not only had vegetables, but they continued to bear till frost. It is evident that in the clay belt of middle Georgia, progressive farmers will all of them soon resort to subsoiling with dynamite. It is faster, more simple, less expensive and far less dangerous than often supposed to be. The public is invited to come at any time and see my apple trees, one year old, that have put on new growth of from 5 to 7 feet in one year. They were planted last spring (consider the dry year) in holes blasted with half stick of dynamite."

J. H. Baird, superintendent of the famous Hale Georgia Orchard Company, Fort Valley, Ga., operating the largest peach orchard in the world, writes under date of November 16th, 1911:

"We have been subsoiling with dynamite for tree planting for three years; the results have been very satisfactory indeed. Just how long the benefit of breaking this hard pan will last is a problem. Our first dynamiting three years ago shows up excellently on our trees and up to this time they are much in advance of those not dynamited. I should think at least one year. I believe the results in subsoiling in this manner will last eight to ten years, and it is my intention now to use dynamite in our old orchards at their very first appearance of 'going back.' I am sorry that I can not give you more information on this line, but my experience with dynamite, as stated above, is only three years old. All agriculturists know that in order to get greater yields the land has to be broken deeply and the new way of doing things is to cultivate less land and grow more per acre."

The preceding letters prove that the theory is supported by facts.

But one obstacle seems to remain to the general adoption of dynamite for subsoiling, and that is the fear that some farmers entertain about using dynamite. Dynamite has obviously the power to injure—so has gasoline, or a shotgun, or a high-spirited horse, but all these utilities are handled regularly by thousands of people without injury and the same is true of dynamite. There are thousands of farmers throughout the country using dynamite without injury. We occasionally hear of a farmer being hurt or in rare instances killed by the use of dynamite, but the records show that out of approximately 500,000 regular users of dynamite throughout the country, including miners, quarrymen, contractors and farmers, there was a casualty list in 1910 of less than one-eighth of 1 per cent. This low accident record is due to the careful following of instructions put out by all manufacturers of dynamite.

It is simply necessary to remember that dynamite is a powerful explosive and handle it accordingly, but there is no reason why any man of common sense should not use dynamite for a lifetime without injury. Dynamite is so difficult to explode that in practice it is necessary to discharge it by the explosion of a fulminate cap. Because of its insensitiveness to shock, dynamite will not explode if dropped on the ground, as many people erroneously believe. The ordinary dynamite cartridge is 8 inches long, 1¼ inches in diameter and consists of a paper shell inclosing the dynamite, which looks like brown sugar.

Full information as to the safe and efficient handling of dynamite can be had from the various manufacturers of same.

Cements for Emery Wheels.—1. Cut up 10 parts of gutta percha, mix with 50 parts oil of turpentine (or heavy benzol) and let stand aside for several days, shaking occasionally. Melt 30 parts of Syrian asphalt and add gradually to the solution. Apply at once and rub down with emery powder. 2. Melt together 80 parts resin, 8 parts venitian turpentine, 2 parts paraffin, and 10 parts gypsum. Use while hot. 3. Heat on water bath 10 parts venitian turpentine, 8 parts oil of turpentine, and 62 parts quick drying copal (or resin) varnish. Remove from the bath and just before the mass gets cold add 20 parts of asphalt caoutchouc cement (see above). This cement can be used while cold.—*Techn. Rundschau.*

Correspondence

[The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.]

The Winning of the Nobel Prizes as Criterion of the Contributions of Nations to Human Progress

To the Editor of Scientific American Supplement:

Ten years have passed since the distribution of the Nobel prizes began. Alfred Nobel (born 1833) died December 15th, 1896. His will, a model of brevity, is dated November 27th, 1895. He willed that the interest on his millions should be distributed among those men who had done the greatest service for humanity. Corresponding to his own line of work, he believed that these greatest services lay in the fields of physics, chemistry, physiology, medicine, literature, and the peace movement. The fund therefore was divided into five equal parts, to be awarded for the most important discovery in the realms of physics, chemistry, physiology, or medicine, for the highest literary work, and for the most notable contribution toward diminishing standing armies, increasing peace congresses, and promoting the brotherhood of man.

The distribution of prizes began ten years ago. Several prizes have been divided, although in the will nothing was said about dividing them in any way.

Now it is interesting and perhaps instructive to see how the sixty-two prizes have been distributed among the nations of the world. For after making all allowances for personal opinions, etc., it will hardly be denied that the total awards, covering a period of ten years, will give some indication of the contributions from the different nations to the culture and progress of the world.

Certainly the distribution of the Nobel prizes has met with criticism, even severe criticism. In the first place, a portion of the capital was appropriated for the acquisition of land, erection of buildings and the appointing of scientific men and officials; in short, for a whole system of institutes for the sole purpose of judging who should receive the prizes.

That the decisions of the judges should be criticised is only natural. Even among a body of men working for a common end there will be a variety of opinions as to method of attaining that end; as for example in a board of directors, men in complete sympathy as far as their work is concerned. How then could such a board be free from criticism, which had such an extremely difficult task to perform? The testator failed to make arrangements for the awarding and distributing of the prizes, but that omission did not relieve the executors of the burden of arranging these details.

The assigning of the prizes is undertaken by various organizations. In physics and chemistry the Swedish Academy of Science is the distributor; in medicine, the Carolin Institute, Stockholm; in literature, the Swedish Academy (not identical with the Academy of Science); and the peace prize is awarded by a committee of five members of the Norwegian Parliament (Storthing).

All these bodies are open to receive suggestions, and it will be readily believed that they are overwhelmed with such, since the prizes amount to $42,880 each. In fact, it became necessary to restrict the sources from whence suggestions would be considered. These restrictions, however, are by no means narrow. In the first place, the nominee must be recommended in writing by a recognized body; or recommendation may be by a Swedish or a foreign member of the Swedish Academy of Science; or by a holder of a Nobel prize; or by *savants* who have been especially invited by the Academy to make such recommendations.

Nominations for the physics and chemistry prizes are received from the professors of physics and chemistry at the universities of Upsala, Lund, Christiania, Copenhagen, Helsingfors, and at the Technical Institute in Stockholm; for medicine, from the professors in the Caroline Institute for Medicine and Surgery. For these three divisions further proposals are considered from professors of at least six foreign universities, selected by the Swedish Academy of Science. For literature suggestions are received from former prize winners; from members of the Swedish Academy; from the Académie Française, and strangely enough, from the Academy of Spain. For the peace prize the list of nominators is very long and includes former winners, members of Parliament and governments of various nations, members of the Interparliamentary Union, of the International Peace Bureau, members and associate members of the Institut de Droit International, professors of law, political sciences, history, and philosophy at universities.

The awarding of the literature prizes has come in for most criticism. The very first award of the Swedish Academy in 1901 to Sully Prudhomme, the Frenchman, caused great astonishment. Oscar Levertin, the literary historian, felt that the prize jury in its exclusively bureaucratic-academic make-up was on the way to turn the ideal purpose of this international foundation into a straight tool of pedagogical doctrine. And recently the temperamental German-Swedish author, Adolf Paul, claimed that the Swedish Academy had made out of the Nobel fund an old men's home for literature and a workhouse for men of letters.

Certainly the awards in literature may have given good cause for some expressions of disapproval.

Especially to be regretted is it that Nobel's wish to reward young talent and so give youth some freedom from material cares has not been regarded. Often enough the Swedish Academy has been satisfied to indorse a recognition long ago granted in literature to an author full of years of work. And yet it is just such procedure that has aroused least criticism; for example, when Paul Heyse was awarded the prize.

The difficulty of recognizing young talent is so enormous that up to now no body of men has succeeded in this matter, as evidenced by the history of all prizes for literary talent. Furthermore, literary talent is of such a nature and dependent on so many factors, that it would be hard to contradict an affirmation that the winning of a prize which should insure the comforts of life, might dry up the poet's well-springs. As yet we know far too little about the laws of literary inspiration to give any decided answer in this matter. Certainly the Swedish Academy might have rendered different decisions, but whether these would have met with less criticism is very questionable. And in spite of the good intentions of Nobel, we may question whether his method is the best for promoting literary and poetical talent.

The distribution of the peace prizes by the Norwegian Storthing has given rise to much less discussion. Of course, there has been expression of different opinions, but not the bitter strife that has taken place over the literary awards. For it is manifestly easier to determine which man has rendered greatest service to the cause of peace than to determine who has produced the literary work of highest idealism.

In the fields of chemistry, physics, and medicine it has not been so difficult to reach a consensus of opinion, and in fact, least criticism had arisen over these awards.

But, however we may criticise the awards, nevertheless after a period of ten years, in which fifty prizes have been awarded to sixty persons, it is surely allowable to attempt to measure the cultural achievements of the different nations by the distribution of these prizes.

	Physics.	Chemistry.	Medicine.	Literature.	Peace.	Total Prizes.
Germany	3(2½)	6	4(3½)	3	......	16(15)
France	4(2)	1	2(1½)	2(1½)	3(3/2)	12(7½)
England	2	2	1	1	1	7
Holland	3	......	......	......	......	3
Italy	1(½)	......	1(½)	1	1(½)	4(2½)
Switzerland	......	......	1	......	3(3/2)	4(2½)
Sweden	......	1	......	1	1(½)	3(2½)
Denmark	......	......	1	......	1(½)	2(1½)
Spain	......	......	1(½)	1(½)	......	2(1)
United States	1	......	......	......	1	2
Austria	......	......	......	......	1	1
Belgium	......	......	......	......	1(½)	1(½)
Norway	......	......	......	1	......	1
Russia	......	......	1	......	......	1
Poland	......	......	......	1	......	1

That Germany stands ahead of France is not to be explained by her closer proximity to the Scandinavian countries. Rather is it sufficiently well known that in Sweden, Norway, and Denmark there is a strong preference for French culture. So that if up to the present Germany has received the lion's share of the Nobel prizes, she may feel justifiably proud.

On the other hand, it must not be overlooked that Germany's awards have been obtained for achievements in physics, chemistry, and medicine, fields in which German science marches in the van. Certainly they could not have gained the first prizes in all fields. If the prizes were for artistic achievement—for example, sculpture—Germany would have had to concede the palm to her western neighbor France, and perhaps the like would have been the case of several sciences in which the analytical spirit plays the leading part. Therefore the Germans should be careful to avoid the danger of supposing themselves to be the leading nation in all lines of culture or even in all the sciences merely on account of their participation in the distribution of the Nobel prizes.

Two things are of interest in the above list; one the poor showing of Austria (due possibly to the fact that prominent German-speaking scientists are appropriated by Germany), and secondly the position of the United States, which appears with only two prize winners, of whom one is ex-President Roosevelt, who was awarded the peace prize by the Norwegian Storthing, chiefly on account of his having arranged the peace of Portsmouth between Russia and Japan. That he is at heart no real friend of peace is plainly shown in his repeated speeches upon the necessity of stronger navies, upon the meaning of national honor, and upon other warlike themes. For this reason the awarding of the prize to him brought forth more criticism than any other award in this group.

Conceding, however, the full number, two, this is of sixty a very small percentage. A nation with a population of ninety-three millions, obtaining but one-thirtieth of the Nobel prizes so far awarded! Even Russia acquires almost as many, and she is looked upon as standing far behind the United States in matters of culture, although having about the same population. Thus it appears clear that neither science nor literature has as yet reached a very high state of development in America.

The case of science is visibly improving. What the State governments and the millionaires of the country can do in order to make working conditions more favorable is being done, as everybody knows, to the fullest extent. Of course, money alone does not improve science nor call forth knowledge. But the will to do is now present, and several important achievements in various scientific fields have been gained by Americans. Yet those surpassing scientific deeds which break forth almost instinctively from a carefully trained mind devoted entirely to its scientific field, but which develop to fullest being only through working out of much detail or by many experiments, have not appeared in America. Such achievements can only grow in a soil of a scientifically rich and highly developed life. Such it is now being sought to create in America; it is not impossible that it will be brought about in the more or less distant future.

Furthermore, it is not very flattering for America that, besides Roosevelt, her only citizen to be awarded a Nobel prize is Prof. Michelsen, who was born in Germany.

Of the twenty-four prizes so far distributed in physics and chemistry, no fewer than eight are for discoveries in the field of radio activity. This new and exceedingly difficult yet most promising field has scarcely been touched by the Americans, perhaps for the reason that the scientific geniality absolutely indispensable in workers in this field, the equally necessary versatility, and the ability to follow a line of thought into neighboring fields, are less frequently found in American scientific circles than in European.

On the other hand, the prospects for America are by no means bad. When the favorable conditions which have been created by these marvelous endowments, especially during the last ten years, have had their effect on one generation even, it is more than possible that America may not only make a good average showing, but may bring forth extraordinary creations.

For the development of American literature the outlook is less favorable. It is significant that it has been unrecognized by Nobel prizes, and there are many reasons for believing that it will go unrewarded for another decade. For the last half century it has remained without scarcely any notable production. Americans readily account for this in that as a nation they have had such tremendous economic problems to deal with that they have had no time at all to devote to intellectual things. But how has it come about that American science stands on a far higher plane to-day than it did fifty years ago, while almost all the famous names in American literature appeared before 1860?

In the history of the literature of every country there are periods of diminished literary creative power. In young nations, however, this is a relatively rare phenomenon. Furthermore, European nations have also been pressingly occupied with economic problems in the last half century, but still they can show meritorious literary productions.

The Dutch occupy a high place in the list of nations. In spite of their small numbers, they have gained three prizes. All three have been awarded to physicists: Lorentz, Zeeman, and Van der Waals. Prof. van't Hoff, Dutch by birth, was called to the University of Berlin in the 90's and is a member of the Berlin Academy of Sciences.

If since the beginning of the nineteenth century there had been in existence a fund like the Nobel prize, we should have had a good means of estimating the contributions of the different nations to the cause of progress during the past century. Of course, as we said above, this method is not entirely sufficient, but it is at least indicative.

The distribution of the prizes in the first decade of the twentieth century presents an interesting picture. The Germans especially have reason to feel gratified. Let Americans see to it, so far as it lies in the popular power, that by grants for scientific research, and especially by cultivating those traits which promote intellectual life, America attains to a higher place in the next decade and maintains it in the future.

Ernest Schulze, Ph.D.

Large Induction Coils.—Some remarkable induction coils have lately been produced by Prof. Klingelfuss of Basel, Switzerland. Coils designed for the Potsdam Astro-physical Observatory and the Vienna Technical School give at their extreme capacity a spark 50 inches long. At this distance the voltage of the current necessary to cross the gap is something over one million.—*Electr. Eng.*

Construction of Conic Sections by Paper-folding*

By Alfred J. Lotka.

A method has been described[1] for constructing a parabola as the envelope of the creases formed on folding a piece of paper in such manner that a fixed point always falls upon a fixed straight line.

The other conic sections also can be similarly obtained, if for the straight line a circle is substituted[2], as is shown by the accompanying examples (Figs. 2 and 3) and by the following analytical demonstration.

Referring to Fig. 3, let C be the center of the fixed circle, and P the fixed point.

Bisect $C P$ in O, and make O the origin of a system of rectangular co-ordinates, with $O P$ for X axis. Let $O P = x_o$.

Then the paper is so folded that P falls upon some point Q of the circle.

If $x_1 y_1$ are the co-ordinates of Q we have:

$$(x_1 + x_o)^2 + y_1^2 = R^2 \ldots\ldots\ldots\ldots\ldots (1)$$

where R is the radius of the fixed circle.

If $x_2 y_2$ are the co-ordinates of the mid-point S of $P Q$, then

$x_1 = 2x_2 - x_o$

$y_1 = 2y_2$

Substituting these values in (1.) and simplifying:

$$x_2^2 + y_2^2 = \frac{R^2}{4} = r^2 \text{ say}$$

i. e., the point S lies upon a circle having its center at O, and a radius $r = \dfrac{R}{2}$.

Now the crease produced is evidently $R T$, perpendicular to $P O$ in S. Its equation is

$$y - y_2 = \frac{(x_o - x_2)}{y_2} \cdot (x - x_2).$$

Rearranging and putting r^2 for $(x_2^2 + y_2^2)$,

$$x_2(x + x_o) = r^2 + x x_o - y y_2.$$

Squaring

$$x_2^2 (x + x_o)^2 = r^4 + 2r^2 x x_o + x^2 x_o^2 - 2 y y_2 (r^2 + x x_o) + y^2 y_2^2.$$

Putting $x_2^2 = r^2 - y_2^2$, simplifying, and arranging as a quadratic in y_2

$$y_2^2 \left\{ y^2 + (x + x_o)^2 \right\} - 2 y_2 y (r^2 + x x_o) + r^2 (r^2 - x^2 - x_o^2) + x^2 x_o^2 = 0 \ldots\ldots\ldots (2)$$

For a given pair of values of x and y, equation (2), gives either two complex, two real and different, or two real and equal roots for y_2.

This means that the number of creases which can be produced through a given point in the manner specified is either 0, 2 or 1.

The points through which only one crease can be made evidently lie on the envelope of the series of creases, the single crease through each being tangent at such point to the envelope, so that the condition for this envelope is given by the condition for the equality of the roots of (2), viz:

$$4y^2 (r^2 + x x_o)^2 - 4 \left\{ y^2 + (x + x_o)^2 \right\} \left\{ r^2 (r^2 - x^2 - x_o^2) + x^2 x_o^2 \right\} = 0$$

$$r^2 y^2 + x^2 (r^2 - x_o^2) - r^2 (r^2 - x_o^2) = 0$$

$$\frac{x^2}{r^2} + \frac{y^2}{r^2 - x_o^2} = 1.$$

Hence the envelope is an ellipse or a hyperbola, according as $r > x_o$ or $r < x_o$, i. e., according as P lies within the fixed circle, or outside the same.

The special cases $x_o = 0$ and $r = \infty$ may be left for discussion by the reader, who may also, as an exercise, work out a purely geometrical proof of the construction here given.

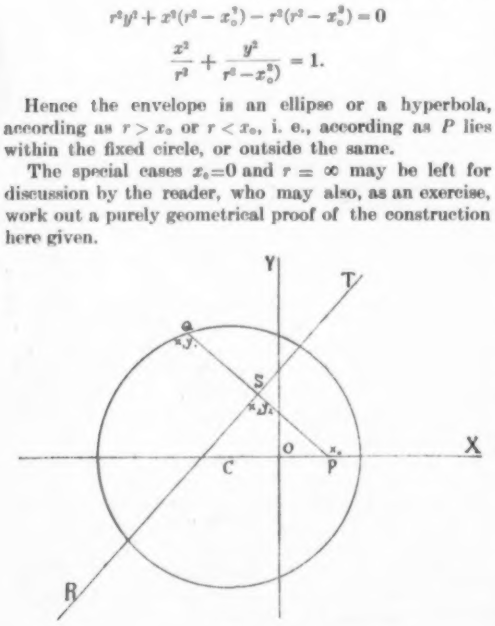


Fig. 1.

* Reproduced from *School Science and Mathematics*.

[1] S. Row (W. W. Beman and D. E. Smith) Geometric Exercises in Paper-Folding, 1901, p. 116. See also Hardcastle, Jn. Brit. Astron. Assoc., May, 1910.

[2] It is, of course, necessary to use translucent paper (tracing paper), or, if using opaque paper, to mark the fixed point on the back of the sheet, and on the edge of a perforation made in the same.

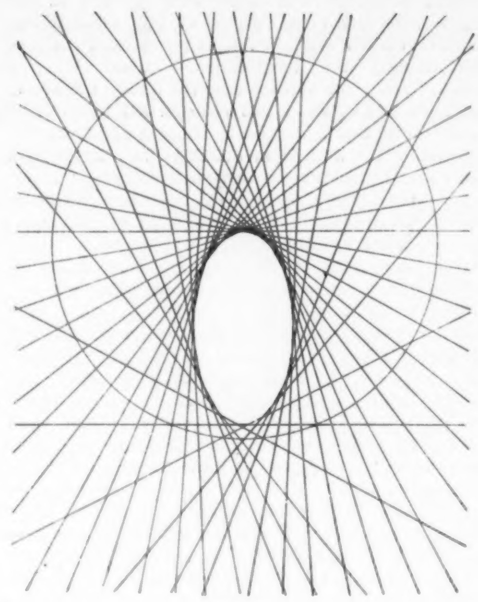


Fig. 2.

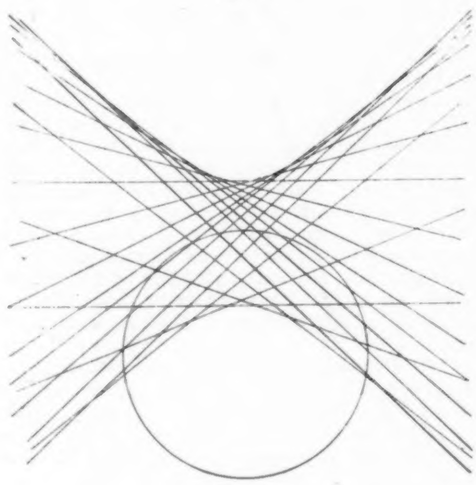


Fig. 3.

Science Notes

The First Eraser.—According to *Gummi-Zeitung*, India rubber was used for the first time as an eraser in 1770, when a very small piece was sold for three marks. It was, however, many years later before it was put into general use. Prior to this the crumb of bread was used for erasing purposes.

Preservation of Timber in the United States.—In 1910 over sixty-three million gallons of creosote and nearly seventeen million pounds of chloride of zinc were used in preserving timber in the United States. There were also used small quantities of corrosive sublimate, water gas tar, crude oil and refined coal tar.—*Wood Craft.*

Metallic Deposit on Aluminium.—The bath used for this purpose consists of a solution of anhydrous salts of copper, nickel or tin in anhydrous wood alcohol. The aluminium to be coated has to be rubbed off with some fatty or greasy metallic polish, the fat to serve as a protection against oxidation. It is then dipped into the solution mentioned. The alcohol dissolves the greasy substance, and the copper, nickel or tin forms a coating which adheres firmly to the aluminium.—*Chem. Tech. Rep.*

The Chemical Composition of Sauerkraut.—Four different samples of sauerkraut have been subjected to a chemical analysis with the following results: Water, 88.00-90.84 per cent; protein, 1.39-1.68 per cent; fat, 0.28-0.38 per cent; lactic acid, 1.22-1.78 percent; dextrose, 0.00-1.31 per cent; mannose, 0.80-1.16 per cent; crude fiber, 0.87-1.02 per cent; ashes, 1.40-4.40 per cent, and sodium chloride, 0.78-3.31 per cent. Mannose seems to form an important constituent of this dish, its quantity amounting to about 10 per cent of the dry solids.—*Zeitschr. f. Unters. d. Nahr. Genussm.*

International Photographic Exhibition, 1913.—It is proposed to hold a great photographic exhibition at Munich, Germany, from May the 15th to October the 15th, 1913. The exhibition will include artistic photography, reproduction technique, book printing and lithography, although the largest sections will be devoted to the photographic trade and industry and the graphic arts. The preparations will be placed under the control of Prof. Emmerich of the *Süddeutscher Photographen Verein E. V.*, who supervised the arrangements of the exhibition held in Munich in 1907 with so much success.—*Abels Photogr. Weekly.*

Trade Notes.

Fastening Oil Colors to Enameled Palettes.—A cement for this purpose is made as follows: Stir 2 parts of rye flour in 6 parts of hot water, then add 1 and let cool down. Finally add 2 parts per thousand pure carbolic acid.

Linoleum Cement.—Melt in a suitable vessel 70 grammes colophony, remove from the fire and stir until cooled off somewhat, then add 10 to 12 grammes castor oil and 13 to 16 grammes alcohol (90 per cent), stirring the while. Apply while still warm, or if kept in the dry state it must be heated first before using. The cement hardens quickly and has a wonderful adhesive power.—*Gummi Zeitung.*

Moving Pictures in Japan.—In Yokohama as well as throughout the empire the moving picture show is taking the place of the old-time theater. The price of admission is sometimes 2½ cents, but usually 5 cents. There are also numerous traveling picture shows. These concerns, according to a consular report, do a large film exchange business, mostly with European manufacturers. An American film is seldom seen, although investigation leads to the belief that the public would be very glad to see more characteristic American views.

Wood Required to Make One Ton of Paper.—The following estimate of the amount of wood required to make one ton of newspaper is given by H. S. Ferguson: One cord of wood will yield one ton of dry ground wood pulp. Two cords of wood will yield one ton of dry sulphite pulp. In the paper mill 22 per cent of the sulphite and 8 per cent of ground wood is wasted. One ton of paper containing 25 per cent of sulphite requires 25/98 × 2 + 79/92 × 1 = 1.32 cords. One ton of paper containing 22½ per cent sulphite requires 22.5/98 × 2 + 77.5/98 × 1 = 1.30 cords. One ton of paper containing 20 per cent sulphite requires 20/98 × 2 + 80/98 × 1 = 1.28 cords.—*Paper.*

Paper Moldings of Monuments, Reliefs, etc.—The method of taking surface impressions or even true molds of monuments, sculptures, reliefs, inscriptions, etc., with the aid of wet paper seems to be but little known and practised. The following hints taken from *Zeitschrift für Ethnologie* may therefore be welcome and useful to the traveler: The paper most suitable for this purpose is copper-plate paper made of pure tough rags, although the paper used for wrapping oranges has also been recommended. The sheets are well soaked in water and separately laid on the stone which has been previously cleaned and wetted. The sheets are laid one on top of the other, and after each application the paper must be beaten with a brush handle or the like to force it into all the hollows. As this procedure causes a tearing of the paper, thus exposing parts of the stone, more sheets have to be used until the whole surface is covered. Then the whole is given an application of a good paste to be followed by more paper. For large pieces a second coating of size and paper is necessary, as the mold must be strong enough to retain its form after drying. For reliefs of shallow carved patterns a few sheets will suffice, however. Any cracks or cavities in the monument or wood carving which do not form any part of the object must be filled out with clay or soaked paper pulp before beginning the work. In hot weather the mold will be dry in about 24 hours, and it may then be pealed off carefully. During the night it should be kept covered to protect it from the morning dew. When entirely dry it should be given a coating of warm oil; dammara lac has also been recommended. A good paste for binding together the paper may be made in the cold by mixing together 250 grammes of rye flour and 750 grammes powdered and washed kaolin with water. In case the mold should break or tear it must at once be pasted together.

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